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The Effects of Information Availability and Information Management on the Performance of Dismounted Military Teams

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THE EFFECTS OF INFORMATION AVAILABILITY AND INFORMATION MANAGEMENT ON THE PERFORMANCE OF DISMOUNTED MILITARY TEAMS

1. Background

Advanced sensor and display technologies promise to increase dismounted soldier performance and the potential for mission success by providing the soldier with more information about the battlefield and by increasing situational awareness (SA). SA has been defined in many different ways (National Research Council, 1997). Endsley (1988) describes it as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."

For the soldier, SA entails both knowledge of the larger battlefield (global SA) and awareness of the environment that immediately surrounds him (local SA). SA can be affected by many factors. Decreases in awareness can be affected by too much information as well as too little. It can be affected by the technology used to display this information and the format in which the information is displayed. Environmental factors and increases in physical and cognitive workload and stress may well compound the degrading effects of an information display that is poorly designed.

It is expected that in the future, much of the information about the battlefield will be presented to the soldier visually on a helmet- or head-mounted display (HMD). Research has shown that information presented visually on an HMD can enhance position determination and increase navigational efficiency by as much as 22% over conventional navigational tools (Glumm et al., 1998).

Currently, dismounted soldiers navigate with a lensatic compass and a paper map. They count their paces to determine the distance they travel. They use a protractor to calculate distances and bearings to objectives and to plot the position coordinates of objects and other units within their area of operation. Such manual computations and notations are time consuming, subject to error, and may cause significant increases in mental workload.

In today's battlefield, command information is typically communicated to unit leaders auditorily via radio transmission. A recent study discovered that soldiers maintained a greater awareness of their position with respect to waypoints, targets, and other units when information was presented visually on an HMD than when the same information was presented auditorily in verbal messages (Glumm, Branscome, Patton, Mullins & Burton, 1999). The participants in this study noted that information transmitted auditorily required more memorization and was not as easily recalled as information presented visually. In the visual mode, graphic representation of object type and position on the HMD may have facilitated "chunking" of information. The same

information, provided auditorily in verbal messages, was presented in series rather than in parallel, and transformation of these data into a meaningful picture of the battlefield that could be easily recalled may have been more difficult.

Research and related literature about memory indicate that information must be rehearsed in order for it to be retained. Even with rehearsal, memory of this information can decay over time. The more information that is stored in short-term or working memory, the more rapid this decay and the lower the probability of correct recall (Van Cott & Warrick, 1972). According to Card, Moran, and Newell (1983), the visual image stored in working memory decays more rapidly than the auditory image store, but the capacity of the visual image store is larger than that of the auditory image store.

As the quantity of information that is provided to the soldier increases, the probability that this information can be accurately recalled is reduced. One would expect that an increase in the frequency at which this information is reviewed or "rehearsed" might increase retention. Also, the more recent the review, the more likely the information would be remembered. The need to frequently refer to a visual display to refresh memory, however, poses an obvious disadvantage. In Glumm et al. (1999), participants noted that they could retrieve auditory information while moving but needed to stop to view the information presented on the HMD. The soldiers claimed that during these moments, they were temporarily distracted and unaware of their immediate surroundings.

The extent to which one task might interfere with the performance of another task depends on many factors. The theory of multiple resources (Wickens, 1984) suggests that a number of resource capacity channels are used to perform a task. These channels have distinct functions, and each channel is limited in capacity. Given this, performance of a task(s) is expected to be affected by the magnitude of the demand on each resource, the efficiency of each resource used in the performance of a task, and the extent to which two tasks performed concurrently might compete for the same resources.

Attentional conflicts and losses in local SA, which are attributed to the use of HMDs, are a concern, as is the potential risk of information overload associated with large increases in the quantity of information provided. Previous field studies (Glumm et al., 1998 & 1999) focused on the effects of HMDs and display modality on the performance of the individual soldier. The present study expands this investigation by examining the effects on mission performance of the availability of information to fire team leaders on an HMD and team support in managing this information.

In the development of the experimental plan, a survey was administered to 42 infantry personnel to identify measures of mission success and associated tactical information that would facilitate mission accomplishment (see Appendix A). A mission description was provided upon which the soldiers would base their responses. The survey asked (a) When the mission is over, how do you know that you have been successful in performing your mission, that is, what are your measures

of success? (b) What information do you need, and (c) when do you need to access this information in order to achieve these measures of success? To help the soldiers answer these questions, lists of measures, types of information, and frequencies at which information could be accessed were provided from which soldiers could choose. The survey participants could also add to these lists as desired. The results of the survey are shown in Appendix A, Tables A-1 through A-3. The list of mission success indicators, shown in Table A-1, and the associated information requirements, also shown in Table A-2, are ordered on the basis of how often each item was selected by the survey participants. The indicators of mission success that were chosen most often were used in the selection of mission tasks performed in the field study that followed. The survey results were also used to derive measures of task performance and weighting factors to compute an overall measure of mission accomplishment. In the present study, most information listed in Table A-2 was available to the participants, except for information judged least likely to affect the achievement of the indicators of success selected. As shown in Table A-3, the survey participants indicated that in order to achieve the selected measures of success, most information needs to be provided only at the operations order (OPORD) and when such information changes.

The present study was a 2 x 2 fixed factor design in which Marine Corps fire teams performed missions in each of four experimental conditions. These four conditions represented a combination of two levels of information availability and two levels of information management. For this study, information availability was defined by how often the team leader could access tactical information displayed on the HMD. The two levels of information availability were at the OPORD and (a) when changes in the position of other units occurred, and (b) when changes in unit position occurred and any other time during the mission. In this study, information management was defined by the level of assistance that team members could provide to the team leader in tracking and recalling information about the battlefield situation and changes that had occurred. The two levels of information management were (a) team leader only and (b) team leader with team support.

The following were hypothesized for this investigation:

1. As the availability of information on the HMD increases, global SA will increase, as measured by the number of correct responses to probe questions and the number of threats correctly acknowledged within the designated distance from the team.

2. As the availability of information on the HMD increases, navigational efficiency will increase as measured by distance traveled.

3. As the availability of information increases, local SA of the team leader will decrease as measured by the number of targets that the team leader detects in the surrounding woods.

4. Local SA of the team as a whole will not be affected by increases in the availability of information to the team leader on the HMD.

2. Objectives

The objective of this field investigation was to examine the effects of the availability of information on an HMD and team support in managing information on SA (local and global), team performance, and perceptions of workload.

3. Method

3.1 Participants

Eight Marine Corps fire teams participated in this investigation. Each of the eight teams consisted of a fire team leader and three team members whose ranks included sergeants, corporals, and lance corporals. The 32 Marine participants ranged in age from 18 to 29 years (mean = 22 years) with approximately 1 to 6.5 years in service (mean = 3.2 years). The military occupational specialty (MOS) of the fire team leaders and their team members was equivalent to the Army MOS of 11B (infantryman). The fire team leaders had approximately 2 to 3 years' experience in that position. Most of the Marines who participated in the study knew each other. Although many had worked together as part of the same company, few had worked together in the teams that had been organized to participate in this study. The voluntary, fully informed consent of the volunteers used in this research was obtained as required by 32 Code of Federal Regulations (CFR) 219 and Army Regulation (AR) 70-25. The investigators have adhered to the policies for protection of human subjects as prescribed in AR 70-25.

3.2 Apparatus

3.2.1 Cross-Country Training and Test Courses

The length of the training course was 600 meters. The course consisted of three segments or legs that intersected four waypoints. Each leg of the course was 200 meters long. The terrain was wooded and except for two moguls, was generally flat.

The length of the test course was 3 kilometers. The course consisted of four legs that intersected five waypoints. The lengths of the legs were 550, 700, 850, and 900 meters. The terrain was flat and densely wooded.

Three-dimensional wooden silhouettes representing enemy and friendly personnel were positioned along each leg of the training and test course. A three-digit number that was painted on each "target" was used to identify it as an enemy or as a friend. This target identification code was changed for each mission to minimize learning effects.

3.2.2 Clothing and Equipment

All participants wore the Marine Corps equivalent of the standard battle dress uniform and the personal armor system for ground troops (PASGT) helmet. All fire team leaders and team members carried a dummy M16 rifle.

3.2.2.1 Helmet-Mounted Display

The fire team leader was the only member of the team to wear an HMD. The HMD was part of a system developed by Rockwell International, called the Trekker (see Figure 1). The weight of the HMD is approximately 0.45 kg (1.0 lb). The headset consists of an occluding, monocular display developed by Kopin. The display is a monochrome active matrix liquid crystal display with 640 horizontal by 480 vertical lines of resolution. Focus and brightness controls are integrated into the headset. The display slides left or right along the top of the unit to accommodate the desired viewing eye. The monocular assembly can be adjusted for eye relief and displaced vertically for stowage. In this investigation, the display was positioned over the non-aiming eye for viewing and was stowed when not in use.

During the study, auditory messages were presented to the fire team leader through two small speakers (Electro Voice, Model 1993) installed in the PASGT helmet. These auditory messages were automatically initiated at predetermined coordinates along the course. They included alerts about changes in unit position, arrivals at waypoint, the status of the global positioning system (GPS) and electronic compass, map access, and probe questions that queried the team leader about the current battlefield situation.

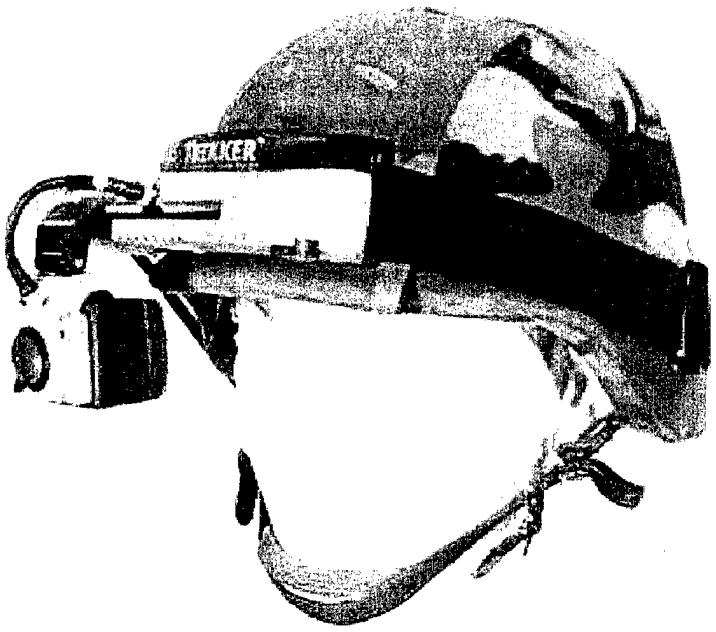

Figure 1. The trekker helmet-mounted display.

3.2.2.2 Digitally Aided Soldier for Human Engineering Research (DASHER) System

The fire team leader also wore a backpack that contained the DASHER system (see Figure 2). DASHER was developed by Sytronics, Inc., of Dayton, Ohio, and consists of a GPS receiver, an electronic compass, and a small Pentium computer. The system is powered by a 12-volt battery and weighs approximately 10 kg (22 lb). The single-board GPS receiver (Micro-Plugger Engine-1), developed by Rockwell International, is capable of providing position information within ±10 m of accuracy. The electronic compass (C100), developed by KVH[1] Industries, is based on magnetic flux-sensing technology. The compass provides ±0.5 degree (±10 mils) accuracy with 0.1 degree (1 mil) resolution.

Figure 2. DASHER system.

DASHER is operated as a real-time interactive device running in a Linux environment. In this study, DASHER automatically initiated mission events and tasks, generated the visual displays and auditory messages, and recorded soldier performance. The major portion of the system

[1]Not an acronym

software is written in Perl and Perl-Tk (a graphical user interface for Perl). GPS and compass programs, written in "C," ran simultaneously, generating information about the location and orientation of the DASHER unit. This information is retrieved once a second by the Perl program. DASHER used a position-based script to simulate connectivity with a command network. For this study, coordinates of mission events were programmed in the computer, along with the positions of waypoints, friendly and enemy units, minefields, potential ambush sites, and areas contaminated with nuclear, biological, or chemical (NBC) agents. A computer routine calculated the distance and bearing of the fire team leader, who wore the DASHER, with respect to the programmed coordinates. A mission event was initiated when the fire team leader was within a 20-meter radius of a position coordinate.

3.2.2.3 Keypad

The fire team leader accessed tactical information and responded to mission events via a keypad that he wore on his belt. The keypad consisted of labeled buttons that included nine information keys and four function keys (see Figure 3). The data that were displayed on the HMD when each of the information keys was depressed are listed in Table 1.

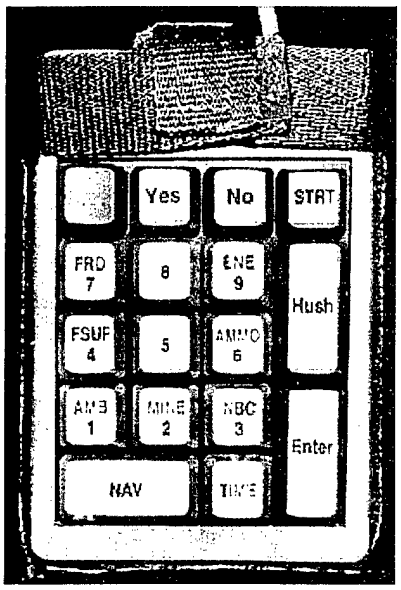

Figure 3. Keypad.

As shown in Figure 3, nine keys were also labeled 1 through 9. These keys, along with three of the four function keys, were used in the performance of mission tasks. The numbered keys were used along with the ENTER button in the target detection-identification task. The ENTER button was also used in conjunction with the MINE, AMB, and NBC keys to acknowledge the position of the fire team with respect to threats in the threat recognition task. The YES and NO keys were used to respond to probe questions that were automatically initiated at predetermined area coordinates along the course. The START button was used to indicate commencement of travel

to the next waypoint, and the HUSH button was used to acknowledge that an auditory message was received.

Table 1. Information keys and data displayed

Key	Information
NAV	distance from path and waypoint, and azimuth orientation
TIME	time remaining to reach the next waypoint
ENE	types of enemy units and distances
FRD	types of friendly units and distances
FSUP	call signs, type, and distances of supporting units
AMMO	clips remaining per man
MINE	distances from minefields
AMB	distances from potential ambush sites
NBC	distances from areas contaminated by nuclear, biological, or chemical agents

3.2.2.4 Information Displays

Figure 4 depicts the map of the area of operation and system status messages that were displayed on the HMD worn by the fire team leader. This information was available to the team leader at all times in all experimental conditions. The map display depicted the waypoints to which the team was to travel and the "optimum" straight-line path between these points. The system status information provided to the right of the map showed the estimated position error (EPE) of the GPS and operational condition of the GPS and electronic compass.

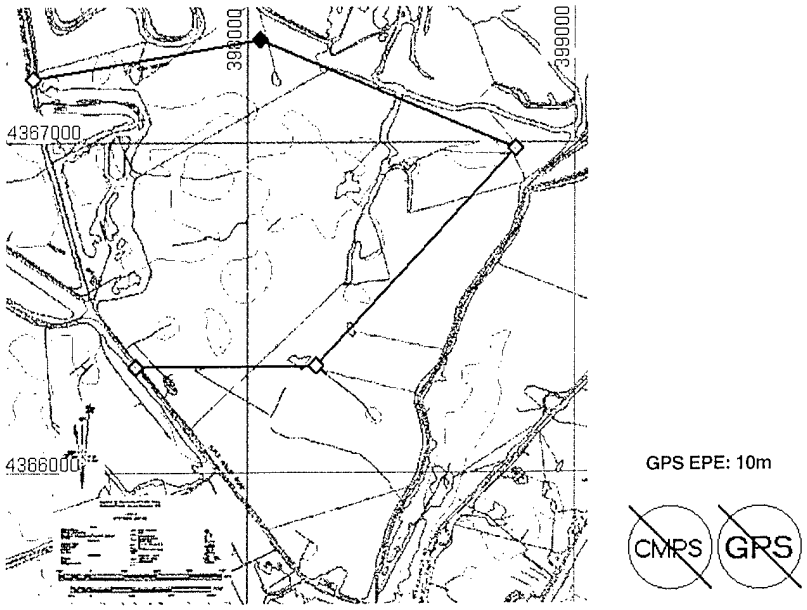

Figure 4. Map display and system status information.

The data displayed on the HMD upon depression of each of the information keys is described next and is depicted in Figures 5 through 13. Only one key could be pressed at a time, and only the information requested was provided. The information requested remained displayed for 1 minute or until another key was pressed.

3.2.2.4.1 Navigation

When the NAV key was pressed, the waypoint to which the team was traveling was darkened. An icon representing the current location and orientation of the fire team leader was overlaid on the map (see Figure 5). This icon, shown as a circle with a pointer, depicted the location of the fire team leader to the left or right of the optimum path and his azimuth orientation. It also showed his distance from the next waypoint and the bearing that he must take to achieve it. Position information was provided in alphanumeric form to the right of the map display.

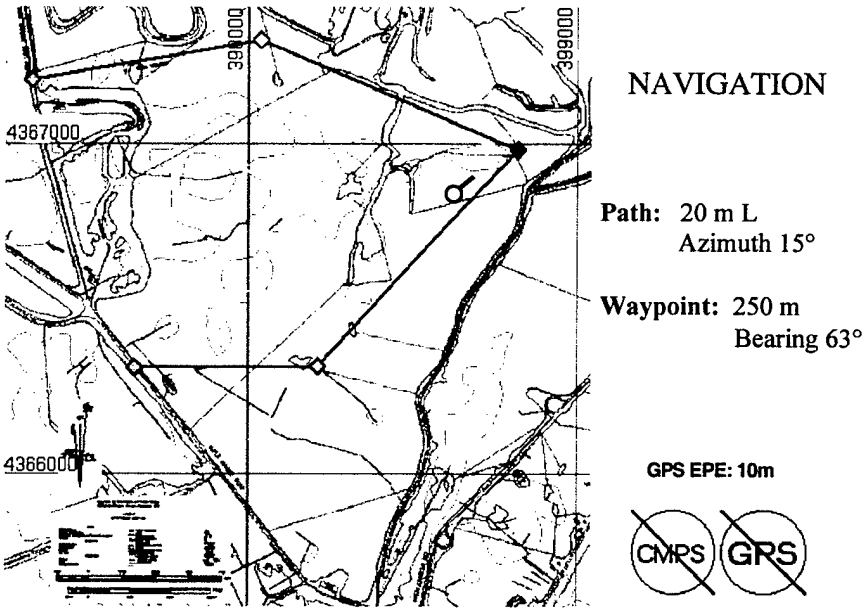

Figure 5. Navigational display.

3.2.2.4.2 Time to Reach Waypoint

Depression of the TIME key provided information about the time remaining to reach the waypoint to which the team was currently traveling and the times designated for travel between subsequent waypoints (see Figure 6). An icon representing the distance of the fire team leader from the next waypoint was also provided; however, unlike the navigation display, this icon did not depict the location of the fire team leader with respect to the "optimum" straight-line path or his azimuth orientation.

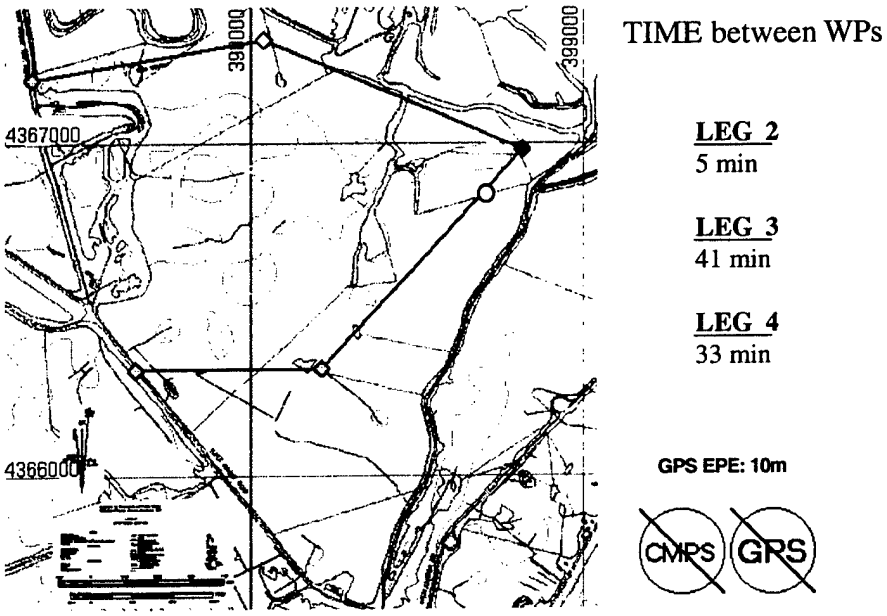

Figure 6. Time to waypoint display.

3.2.2.4.3 Enemy and Friendly

a. Unit Positions

In all conditions, information about the position of enemy units could be accessed by the pressing of the ENE key whenever a change in the position of an enemy unit occurred. Likewise, information about the position of friendly units could be accessed by the pressing of the FRD key whenever a change in the position of a friendly unit occurred. When a unit moved, the fire team leader was provided an auditory message that identified the unit and the new location. For example, "Alert. Change. Enemy light infantry unit has moved to 398100 Northing 4367200 Easting." The message was repeated every 15 seconds to allow time for the new coordinates to be recorded on a paper map.

When the ENE or FRD key was pressed, symbols depicting the type and location of the units were overlaid on the map display (see Figures 7 and 8). The location of the fire team leader with respect to these units was depicted by a circle. Unlike the navigational display, this icon only showed the distance of the fire team leader along the course. It did not depict his azimuth orientation or any lateral deviation from path center. Alphanumeric information about the distance of units to the front of the team was presented to the right of the map. Data about units to the rear of the fire team were not provided although the symbols representing these units remained displayed. For units on subsequent legs of the path, the data represented the distance of the units from the start of the leg upon which the units were situated.

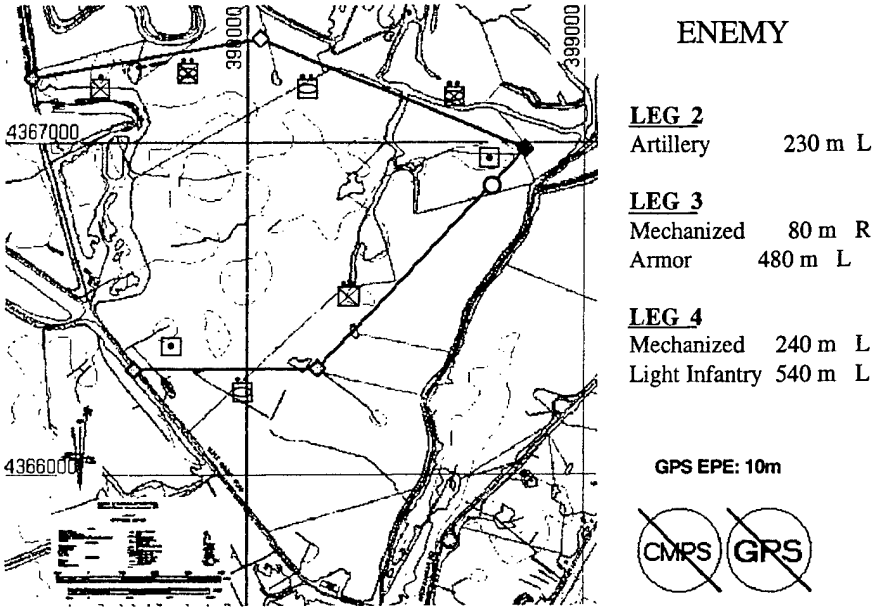

Figure 7. Enemy unit position display.

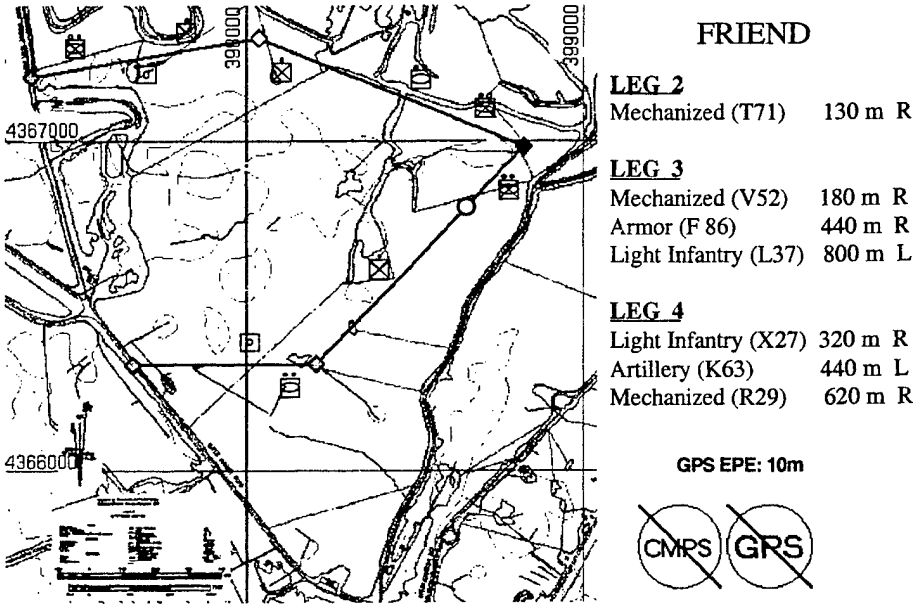

Figure 8. Friendly unit position display.

b. Fire Support

Depression of the FSP button provided information about available fire support within the area of operation. Symbols depicting the type and location of these supporting units were overlaid on the map display, along with an icon depicting the current location of the fire team leader (see Figure 9). No other friendly units were depicted. As in the displays depicting enemy and friendly unit positions, the alphanumeric information presented to the right of the map display represented the distance of supporting units forward of the team. No data were provided about the

position of supporting units to the rear of the team, although symbols representing these units remained displayed. The position of supporting units on subsequent legs of the path represented the distance of these units from the start of the leg upon which the units were situated.

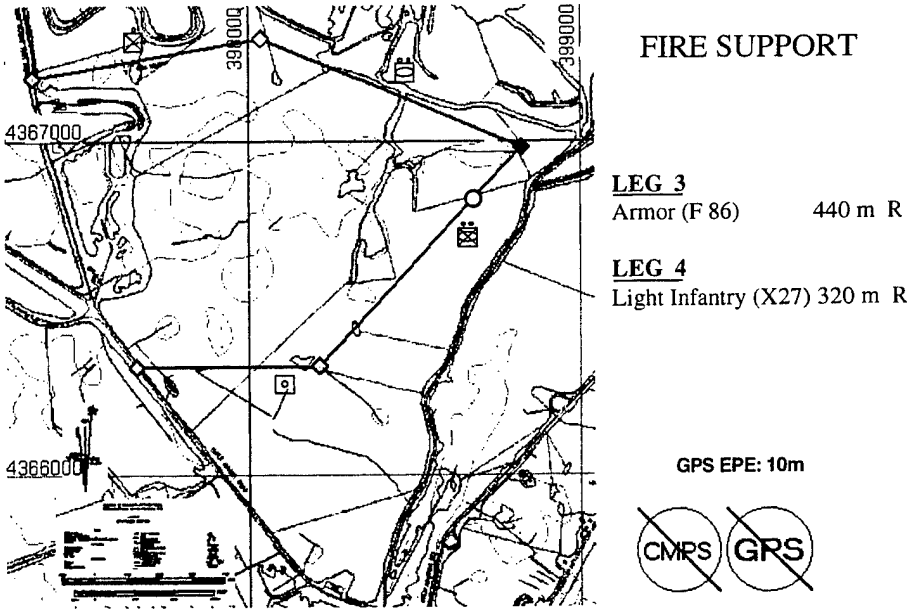

Figure 9. Fire support display.

c. Ammunition Status

Depression of the AMMO key provided information about the current number of clips of ammunition available per team member (see Figure 10). This count assumed an initial distribution of seven clips per man, an expenditure of one clip for each target identified as enemy, and redistribution of the remaining clips among the team members.

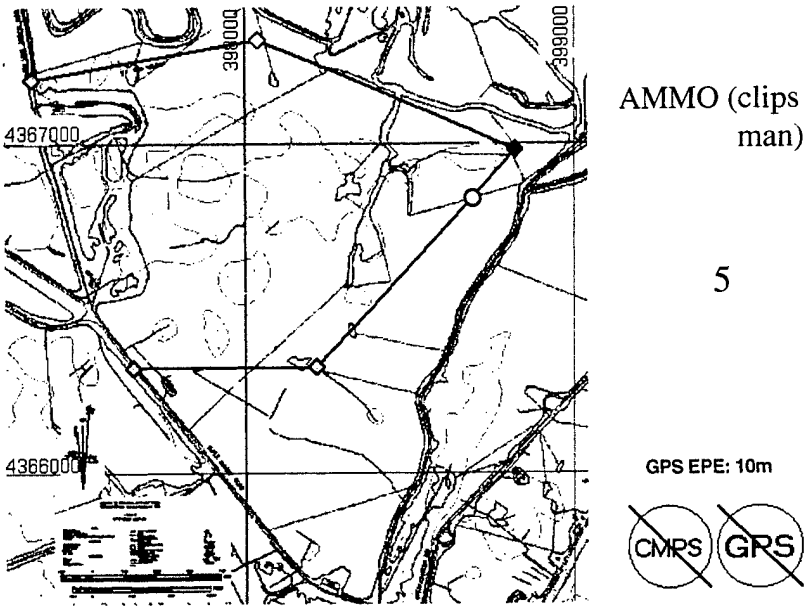

Figure 10. Ammunition status display.

3.2.2.4.4 Threats

Upon depression of the MINE, AMB, or NBC keys, symbols depicting the location of minefields, potential ambush sites, and areas contaminated with NBC agents were overlaid on the map display, respectively (see Figures 11 through 13). Alphanumeric information provided to the right of the map display represented the distance of threats to the front of the team. For subsequent legs, these data represented the distance of threats from the start of the leg upon which the threats were situated. As in other information displays, the location of the fire team leader was depicted by a circle.

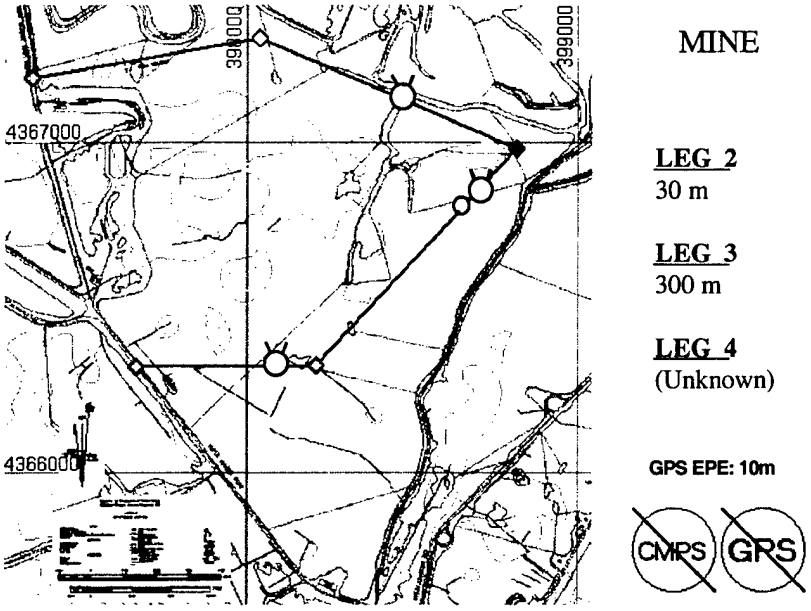

Figure 11. Minefield locations display.

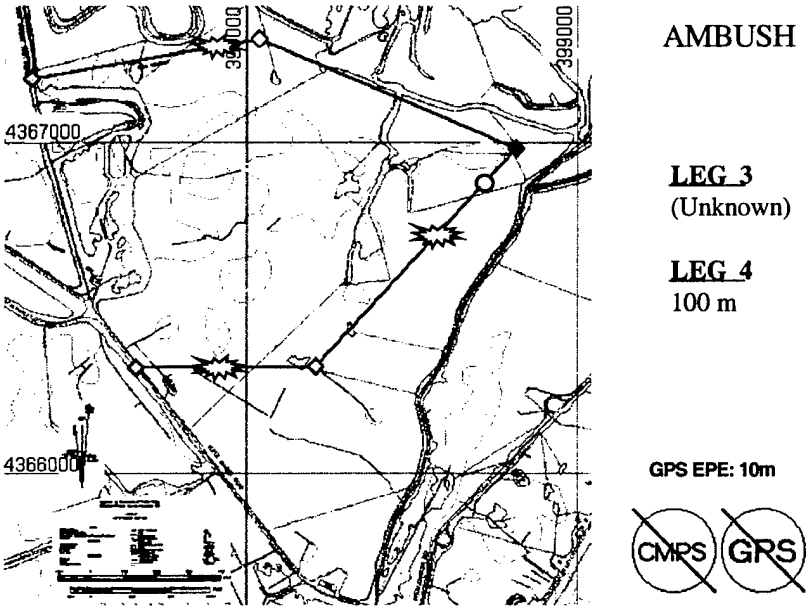

Figure 12. Potential ambush sites display.

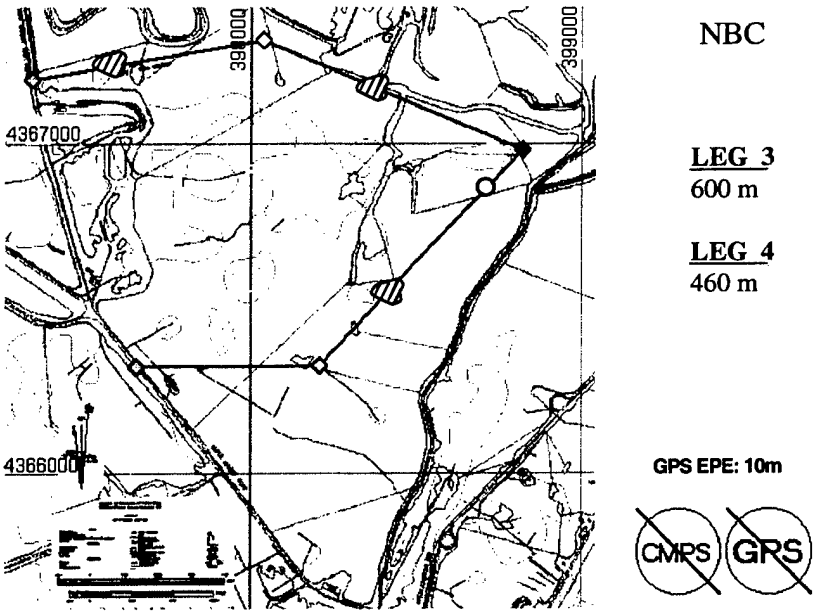

Figure 13. NBC contaminated areas display.

3.2.3 Standard Navigational Equipment

In all conditions, each fire team was provided with standard navigational tools to assist them in navigation and position determination throughout the mission. These tools included a paper version of the map presented on the HMD, a protractor, a lensatic compass, and a hand-held GPS.

3.2.3.1 Paper Map

The paper map had been derived from digital ortho-photography and was accurate to within 0.46 meter (1.5 feet). It depicted streams, marsh, trees and foliage, dirt paths, and improved roads, and other landmarks provided on standard military maps. A legend defining these terrain features and landmarks was included. The scale of the map was increased from the standard 1:50000-meter military map to 1:6000 meters, given that the area of operation in this field experiment would appear the size of a postage stamp on the standard scale map and would lack the needed detail. A protractor, similar to that of the standard military protractor (graphic training aid 5-2-12), was sized to conform to the scale of the map.

The paper map was pre-annotated for each of the four tactical scenarios to avoid errors in transposition. Information provided on the map included the distance and bearing to each waypoint and the time requirements to reach these points. Enemy and friendly unit positions, available fire support and their call signs, and potential threats within the area of operation were also shown. The paper map depicted the battle situation at the time of the OPORD.

In all conditions, access to the paper map was restricted to every 200 meters along the course and when changes in unit position occurred. Auditory messages were automatically presented to

indicate when the paper map could be consulted. Access to the paper map was also monitored by one of the researchers who accompanied the fire team on their mission.

3.2.3.2 Lensatic Compass

A standard military lensatic compass was provided to each team for determining azimuth orientation. The compass has a vertical sight in the lid and a separate lens that the soldier uses to align a landmark and read the bearing.

3.2.3.3 GPS

A hand-held GPS receiver (AN/PSN-11), developed for the military by Rockwell International, was provided to each team. Like that incorporated in the DASHER system, the GPS provided an accuracy of ±10 meters. The GPS was used in the navigational mode and provided information similar to that presented on the HMD. This information included the distance of the user in meters to the left or right of path centerline and his distance and azimuth orientation with respect to the next waypoint.

3.3 Procedures

3.3.1 Experimental Design

The study was a fixed two-factor experiment with information availability (OPORD and anytime) and information management (team leader and team) all as within-subject effects. The experimental condition matrix for this field investigation is shown in Figure 14. The order of presentation of the experimental conditions was counterbalanced (see Table 2).

			Information Availability	
			OPORD	Anytime
		Team Leader	A	C
Information Management				
		Team	B	D

Figure 14. Experimental condition matrix.

Table 2. Order of presentation

Team	Test Period → / Time of Day →	Order of Presentation Day 1 a.m.	Day 1 p.m.	Day 2 a.m.	Day 2 p.m.
1		A	B*	D	C
2		B	A*	C	D*
3		A	D	B	C
4		D	A	C	B
5		C	B	D	A
6		B	C	A	D
7		D	C	A	B
8		C	D	B	A

*The data from these runs could not be used in the final analysis.

3.3.1.1 Independent Variables

The independent variables were information availability and information management. There were two levels of each of these variables. The two levels of information availability were at the OPORD and (a) when changes in the position of other units occurred, and (b) when changes in unit position occurred and any other time during the mission. The two levels of information management were (a) team leader only and (b) team leader with team support.

There were four experimental conditions or combinations of levels of the independent variables. In each of the four conditions, an OPORD was delivered to the fire team leader and his team members before the mission. During the OPORD, the fire teams were briefed about the mission and the current battlefield situation. The team leader was provided with an annotated paper map that included the scenario details. During each mission, access to information on the HMD was controlled by the DASHER system, based on the experimental condition input before each run.

In the OPORD-Team Leader condition, the team was briefed about the tactical scenario at the OPORD, and the team leader was provided time to study the battlefield situation before the mission began. In this condition, the team leader could only access information about enemy or friendly unit positions and then only when the position of a unit changed. Team members could not assist the team leader in keeping track of the different types of information that needed to be recalled during the mission.

The OPORD-Team condition was the same as the OPORD-Team Leader condition except that the team members could now assist the team leader in remembering any or all of the scenario details. In this condition, the team leader could distribute information among his team members and could consult with them any time during the mission. The team members could also assist

the team leader in answering probe questions. They could alert him of the proximity of a potential threat or remind him of the call sign, type, and location of a supporting unit.

In the Anytime-Team Leader condition, the team leader could access any or all information displayed on his HMD at any time during the mission. However, as in the OPORD-Team Leader condition, his team members could not assist him in responding to probe questions or other tasks that required recall of the tactical situation.

In the Anytime-Team condition, the team leader could access information at any time on the HMD and distribute any or all of the information among his team members. The team members could be consulted at any time and could provide full support in response to probe questions or other events that involved information recall.

3.3.1.2 Dependent Variables

The dependent variables included performance in navigating, target detection-identification, probe questions, and threat recognition. A measure of overall mission performance was also computed, and subjective ratings of workload were obtained (see Table 3).

Table 3. Dependent variables and measures of performance

Dependent Variables	Measures
Navigation	Distance traveled (meters) Velocity (meters per minute)
Target Detection and Identification	Number of targets detected and correctly identified by the team leader and the team as a whole
Probe Questions	Sensitivity (d') computed from the number of hits, misses, correct rejections, and false alarms in responses to probe questions
Threat Recognition	Number of threats correctly identified within 20 to 50 meters of team position
Overall Mission Performance	Compilation of scores on missions tasks (see Table 4)
Workload (NASA-TLX[a])	Subjective ratings or workload sources (i.e., mental, physical, temporal, performance, effort, and frustration) and overall workload scores

[a]NASA-TLX = National Aeronautics and Space Administration-Task Load Index

A description of the dependent variables, associated tasks, and measures of performance follows.

3.3.1.2.1 Navigation

Each fire team was instructed to navigate between waypoints as quickly as possible, deviating from the "optimum" straight-line path only as far as necessary to avoid obstacles. Measures of

distance traveled and travel velocity were computed from position information that was recorded once a second by the DASHER system.

3.3.1.2.2 Target Detection and Identification (local SA)

Twenty targets were positioned at random distances along the course. Five targets were situated along each of the four legs. The fire team leader and team members were instructed to identify these targets as enemy or friendly, based on a three-digit number that was painted on each target. The target identification code was changed for each mission to minimize learning effects. When a target was detected, the team member who spotted the target announced "enemy" or "friendly" and stated the target number. The target identification and target number were entered in the computer by the team leader. Performance of this task was based on the number of targets detected and correctly identified by the team leader and those detected and identified by the team as a whole. The number of targets detected by the team leader was assessed as a measure of his awareness of the local situation.

3.3.1.2.3 Probe Questions (global SA)

Twenty-four probe questions were administered to the fire team leader at predetermined coordinates along the course. Six probe questions were administered along each of the four legs. Of these six questions, one question was posed about the position of the team with respect to waypoints and one question about ammunition status. Two questions were posed about enemy and friendly unit positions and unit type (i.e., armor, artillery, mechanized or dismounted infantry) and two questions about available fire support and their call signs. The team leader responded to each probe question by pressing the YES or NO key on his keypad. The team leader could not access information on the HMD until he pressed one or the other key. The signal detection sensitivity statistic (d') was used to analyze responses to probe questions.

3.3.1.2.4 Threat Recognition (global SA)

Threat recognition performance was based on timely and accurate "communication" of information about threats (i.e., minefield, ambush, NBC). Performance of this task was determined by the number of potential threats correctly identified within a designated distance of the team (i.e., 20 to 50 meters). There were 10 threats along the course—two to three threats in each of the four legs.

3.3.1.2.5 Workload

The NASA-TLX was administered to each participant at the end of each mission. The NASA-TLX uses rating scales to assess mental, physical, and temporal demands, performance, effort, and frustration. In this technique, a weight is initially obtained for each of the six workload factors, based on the responses of the participant to pair-wise comparisons among these factors. In these comparisons, the six factors are presented in 15 possible pairs and for each pair, the participant is asked to circle the factor that he or she perceived contributed more to his or her workload experience. The participant then completes rating scales that provide a measure of the magnitude of the workload for each factor. Those factors perceived by the participant to be most

important in his or her workload experience are given more weight in the computation of an overall workload score.

3.3.1.2.6 Overall Mission Performance

Table 4 lists the performance measures and scoring techniques used to compute a measure of overall mission performance. The performance measures chosen to be included in this overall score were selected for their relevance to one or more "indicators of mission success" identified in the earlier survey of infantry personnel who judged these indicators to be most reflective of mission accomplishment. The Situational Self-Efficacy (SSE) scale shown in Appendix B and the Environmental Symptoms Questionnaire (ESQ) shown in Appendix C were used to obtain a measure of the extent to which the team was "prepared for the next mission." The SSE was administered before the mission began. The ESQ was administered before the mission began and after it ended.

3.3.2 Training

The duration of training and testing for each of the eight fire teams was 1 week. Two fire teams were trained and tested during a 1-week period. Training included both classroom and field instruction. Participant screening and orientation was conducted on the morning of the first day, followed by classroom instruction and field training.

3.3.2.1 Participant Screening and Orientation

The military volunteers were briefed about the purpose of the study, the study design, the training and testing schedule, the procedures to be followed, and any risks involved in their participation. All participants were required to read and sign a statement of informed consent. A visual acuity test at far and near distances was administered to the fire team leaders to ensure 20/20 vision in one eye and at least 20/30 in the other eye, corrected or uncorrected. The fire team leaders were also required to pass tests of color and stereo-vision. All participants completed a questionnaire to obtain pertinent demographic information (see Appendix D).

3.3.2.2 Classroom Instruction

Classroom instruction began in the afternoon of the first day. During this period, the fire team leaders and their team members were briefed about the tasks to be performed during their missions, the information needed to perform these tasks, and the equal importance of all tasks to overall mission performance. The team leaders and their team members were briefed about the design and operation of the equipment to be worn by the fire team leader (i.e., the DASHER system, the HMD, and the keypad). All were shown visuals of the information displays and the type of data that each display would provide. The use of the keypad in accessing the various types of information and responding to each mission task was also demonstrated.

All participants received instruction about the use of the standard navigational equipment (i.e., lensatic compass, hand-held GPS, protractor and paper map). At the conclusion of this portion of

the instruction, each team designated one member of the team to use the compass and another member to operate the hand-held GPS. The team leader who would be responsible for plotting changes in unit position on the paper map received instruction about the re-scaled protractor and map, along with practice in plotting coordinates.

Table 4. Measures of overall mission performance

Indicators of Mission Success	Measures	Scoring Technique	Points
(1) Maintained communication up the chain of command	Number of threats correctly reported within 20 to 50 meters of team	Ten (10) threats, each 2.0 points	20
(2) Did not run out of ammunition	Number of correct responses to probe questions about ammunition status	Four (4) probe questions, each 5.0 points	20
(3) All the enemy were destroyed	Number of enemy targets detected and correctly identified	Ten (10) enemy targets, each 2.0 points	20
(4) All the men in my unit survived	Number of casualties (i.e., enemy targets identified as friendly)	Ten (10) possible incidents, 2.0 points deducted per incident	20
(5) Maintained communication down the chain of command	Team ratings of adequacy of information, communication within team, and team performance	Adequacy rated on a 5-point scale: (high = 5; low = 1); mean rating on five questions computed for each team member and summed for team score	20
(6) Seized and occupied terrain	Time to reach Objective (Waypoint 3)	Arrival at Objective within designated time, 5.0 points	5
	Correct response to probe question about ammunition status before arrival at Objective	One (1) probe question, 5.0 points	5
	Number of men in team upon arrival at Objective (based on number of casualties in preceding legs of course)	Four (4) men in team, 2.5 points per man	10
(7) No incidents of fratricide	Number of friendly personnel identified as enemy	Ten (10) possible incidents, 2.0 points deducted per incident	20
(8) Received adequate supporting fires	Number of correct responses to probe questions about available fire support	Five (5) probe questions, each 4.0 points	20
(9) Physically and mentally prepared for mission	Ratings of confidence that the mission will be successful (SSE)	Confidence in mission on 10-point scale (high = 10; low = 1); mean computed for each team	10
	Ratings of symptom severity in pre- and post-test administration of ESQ	For each team member whose post-test rating of severity of two or more symptoms exceeds pre-test ratings by two or more points, deduct 2.5 points	10
(10) Reached waypoints on time	Time to reach each waypoint	Four (4) waypoints, each 5.0 points	20
		Total Score	200

During the training period, the participants also received instruction in completing questionnaires that would be administered during the test period. These questionnaires included the SSE, the ESQ, and the NASA-TLX.

3.3.2.3 Field Training

During field training, each team completed successive runs through the training course in one experimental condition until they reached asymptote in navigation time and targets detected. During each run, the two teams navigated the training course in opposite directions, each accompanied by a member of the research team. After each run through the training course, the researcher re-programmed the DASHER system for a different scenario. The team leader was provided with a new paper map annotated for that scenario, and time was allowed to study the tactical details with his team, as appropriate.

During both training and testing in each experimental condition, each fire team was required to maintain a ranger formation as shown in Figure 15. This formation had been agreed to by the researchers and the Marine Corps participants as appropriate for the mission, the terrain, and the objectives of the research.

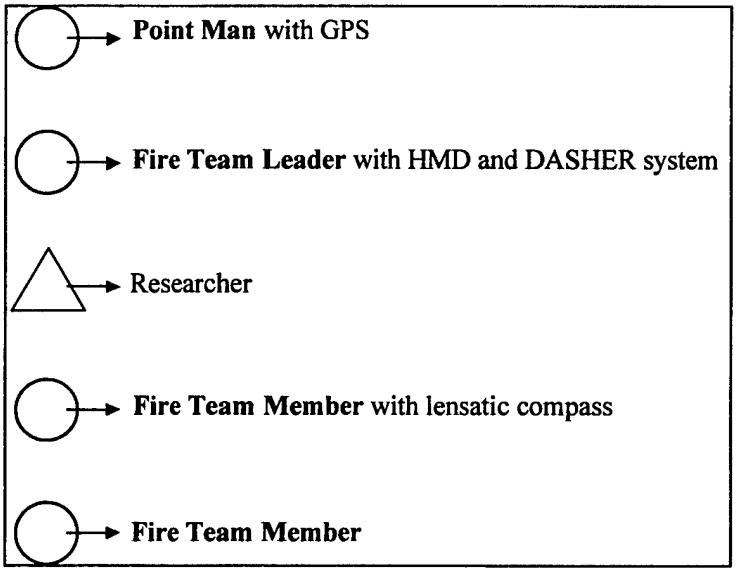

Figure 15. Ranger formation maintained by fire team in all missions.

3.3.3 Testing

Before testing in each condition, an OPORD was delivered to the fire teams by a senior noncommissioned officer. A hard copy of the OPORD was also provided, along with an annotated paper map. After the OPORD and before the test run, each team was provided the time they deemed necessary to prepare for the imminent mission. Immediately before the run, the team leaders and team members were administered the SSE and the ESQ.

Each team was then driven to their respective starting points on the test course. They were reminded of the procedures to be followed during their missions and that each task to be performed was of equal importance. As during training, each team navigated the course in opposite directions, accompanied by a member of the research team.

At the conclusion of the run, the team leaders and their team members were administered the ESQ and the NASA-TLX. The team leaders and team members were also asked to complete post-run questionnaires shown in Appendix F, respectively.

For each day of test, the time between runs in each of the two experimental conditions was approximately 2 hours. During this period, the teams were provided lunch, a rest break, and the OPORD for the next test run.

At the conclusion of testing in all conditions, each team leader was asked to complete a post-test questionnaire.

4. Results

4.1 Frequency of Access to Information

The frequencies with which team leaders accessed information on the HMD in conditions where such access was unrestricted (i.e., Anytime-Team Leader and Anytime-Team) were subjected to an analysis of variance (ANOVA) with level of information management (i.e., team leader and team) as a within-subjects effect. In both conditions, navigational information was accessed more often than any other type of tactical information; however, no significant differences between levels of information management were revealed in the frequency with which the teams accessed information of a particular type.

4.2 Mission Tasks

Performance data obtained for each mission task were subjected to a two-way ANOVA with levels of information management and information availability as within-subjects effects. The results of the analysis follow.

4.2.1 Navigation

The results of the ANOVA of distance traveled and travel velocity data did not reveal any significant effects or interactions of information availability and information management on navigation performance.

4.2.2 Target Detection and Identification

No significant main effects or interactions were revealed in the analysis of the number of targets detected and correctly identified by the team as a whole (i.e., team leader and team members). However, as shown in Table 5, a significant effect of information availability was found for the number of targets detected and identified by team leaders ($F[1,15] = 4.69$; $p = < .05$). This finding indicates that team leaders detected fewer targets during missions in which information could be accessed at any time on the HMD by comparison to missions in which access to information on the HMD was restricted (see Figure 16).

Table 5. ANOVA results of the number of targets detected and identified by team leaders

Source	SS	df	MS	F	*p*
Team	283.3	7	40.471	12.619	0.000
Availability	15.043	1	15.043	4.69	0.047
Management	1.14E-02	1	1.14E-02	0	0.985
Availability*Management	1.673	1	1.673	0.522	0.481
Order	43.886	3	14.629	4.561	0.018
Error	48.108	15	3.207		

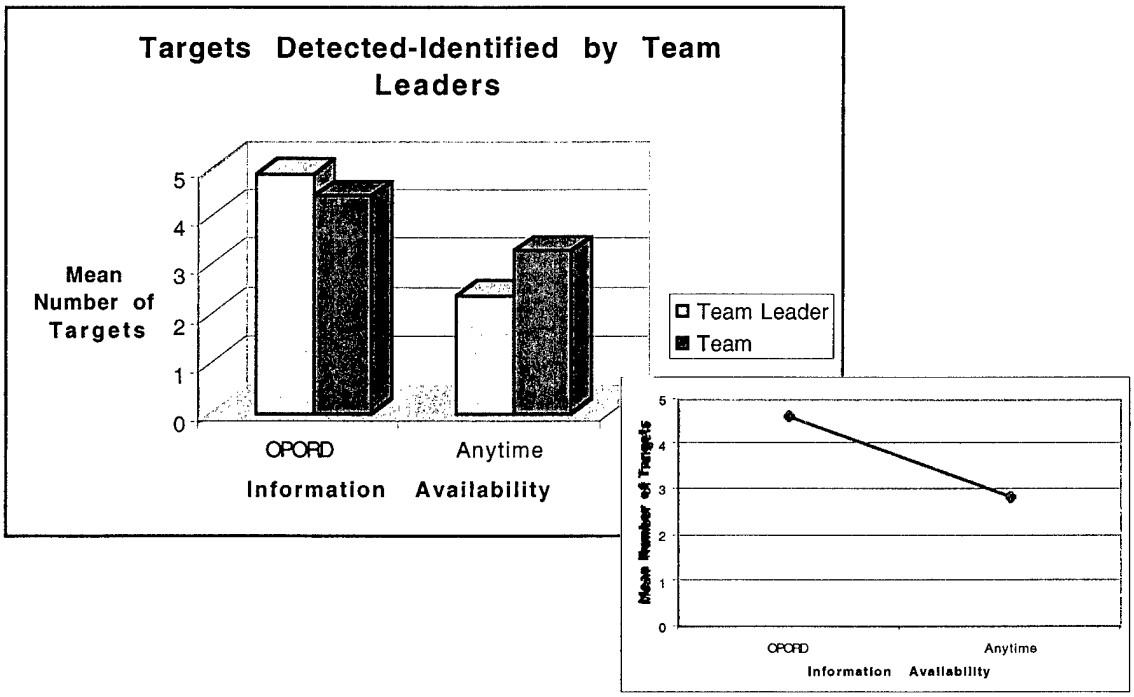

Figure 16. Main effect of information availability on the number of targets detected and identified by team leaders.

4.2.3 Global Situation Awareness (probe questions)

Responses to probe questions were treated as an assessment of information available in the participants' memories. The signal detection sensitivity statistic d-prime (d') was used to analyze the data. Each response was graded as a hit, miss, correct rejection, or false alarm, which are defined as follows:

Hit: Answered "Yes" and "Yes" was correct
Miss: Answered "No" and "Yes" was correct
Correct Rejection: Answered "No" and "No" was correct
False Alarm: Answered "Yes" and "No" was correct

From these scores, conditional probabilities of the participants making a particular response were determined by the following formulas:

$$p[hit] = \frac{number\ of\ hits}{number\ of\ hits + number\ of\ misses}$$

$$p[false\ alarm] = \frac{number\ of\ false\ alarms}{number\ of\ false\ alarms + number\ of\ correct\ rejections}$$

Based on these probabilities, measures of sensitivity (d') were computed by the following formula:

$$d' = z_{p[hit]} - z_{p[false\ alarm]}$$

It was assumed that the information requested in the probe questions was equally probable and normally distributed. The larger the d', the greater the probability that the participant responded correctly and less likely by chance. Measures of sensitivity (d') that are close to or below 0 indicate progressively fewer correct responses and the greater likelihood that correct or incorrect responses were made by chance. Table 6 lists the d' computed for each team by level of information availability and information management. These data show considerable variability among teams in performance in each of the four experimental conditions.

The results of the ANOVA of probe question responses are shown in Table 7 and are illustrated in Figure 17. Technically, the analysis did not reveal a statistically significant effect of information availability ($F[1,15] = 4.224$; $p = .058$); however, the results are suggestive of a potential influence and the need for further study. A decrease in the number of correct responses to probe questions in conditions in which information could be accessed at any time on the HMD would be unexpected. No significant effect of information management or interaction between information availability and information management was found.

Table 6. Measures of sensitivity (d') by team and level of information availability and information management based on probe question responses

Team	OPORD-Leader	OPORD-Team	Anytime-Leader	Anytime-Team
1	2.4865	*	0.9278	0.6849
2	*	-0.2527	-0.7655	*
3	0.6259	0.6071	-0.9679	-0.1134
4	0.4594	0.9063	-0.2538	1.0205
5	1.1503	0.1397	0.3186	-0.5724
6	1.1061	0.9026	0.8794	0.9630
7	-0.3559	-0.3186	0.4946	0.5244
8	1.5913	0.0000	1.6406	1.1938
Mean	1.0091	0.2835	0.2842	0.5326
SD	0.9003	0.5207	0.8955	0.6495

*No data for mission
SD = standard deviation

Table 7. ANOVA results of probe question responses

Source	SS	df	MS	F	*p*
Team	7.925	7	1.132	4.917	0.005
Availability	0.973	1	0.973	4.224	0.058
Management	0.308	1	0.308	1.339	0.265
Availability*Management	0.424	1	0.424	1.841	0.195
Order	3.803	3	1.268	5.507	0.009
Error	3.453	15	0.230		

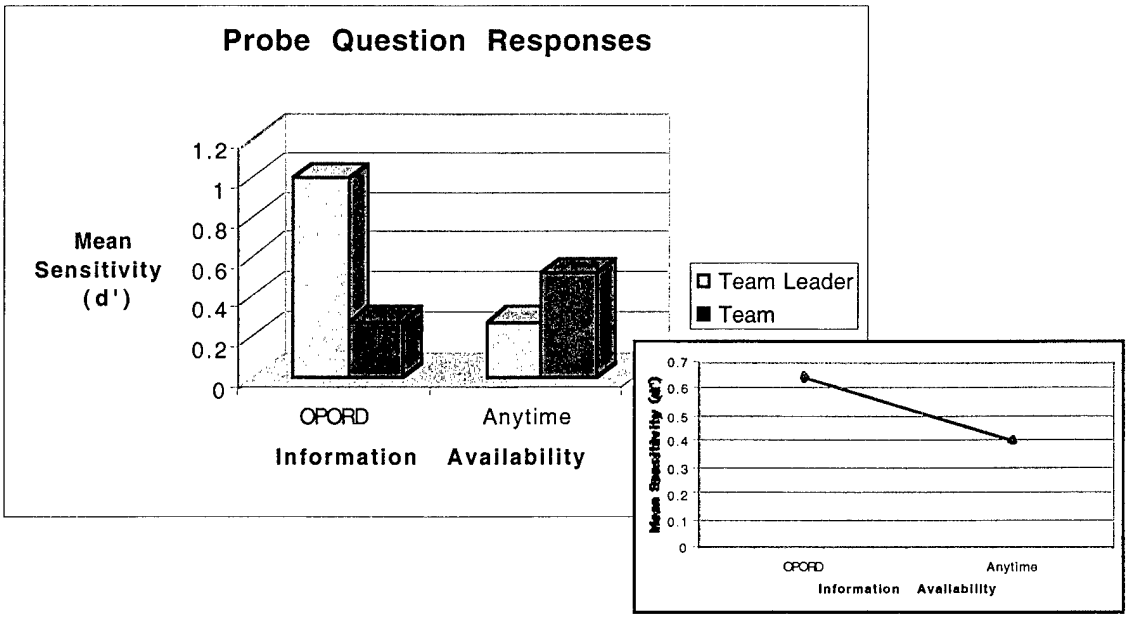

Figure 17. Probe question responses: Mean sensitivity (d').

4.2.4 Threat Recognition

The results of the ANOVA of the number of threats correctly identified and reported within the designated distance of the team are shown in Table 8 and are illustrated in Figure 18. Technically, the analysis did not reveal a statistically significant effect of information availability ($F[1,15] = 4.137$; $p = .06$); however, the results are suggestive of a potential influence and are of particular interest, given the results of the analysis of probe question responses. Further study is needed.

Table 8. ANOVA results of threat recognition

Source	SS	df	MS	F	*p*
Team	133.067	7	19.01	4.748	0.005
Availability	16.563	1	16.563	4.137	0.060
Management	0.427	1	0.427	0.107	0.749
Availability*Management	3.59E-02	1	3.59E-02	0.009	0.926
Order	19.217	3	6.406	1.600	0.231
Error	60.057	15	4.004		

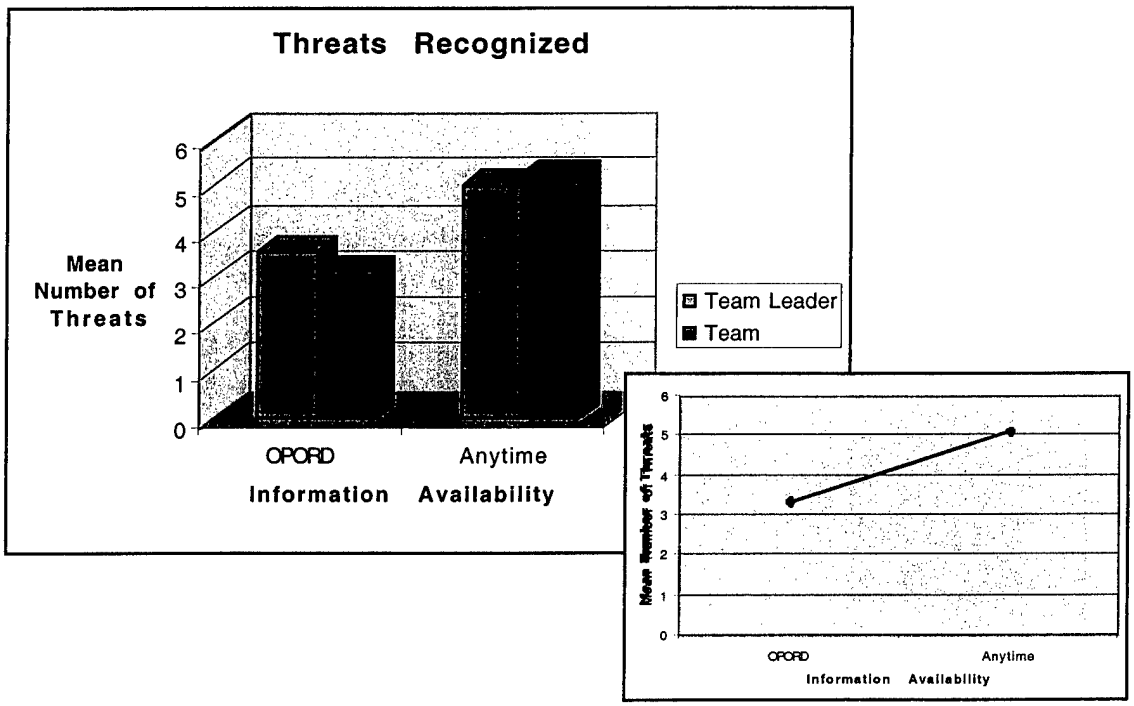

Figure 18. Mean number of threats recognized.

4.3 Overall Mission

For each mission, a measure of overall performance was derived from scores on each of the 10 tasks (see Table 4 for description of measures and scoring technique). The scores on each of these measures were multiplied by a weighting factor derived from the previous analysis of survey responses. The weighted scores were then tallied to obtain an overall measure of mission performance for each fire team in each condition of information availability and management. The tallied scores were subjected to an ANOVA. All effects failed to reach significance at the .05 level of confidence.

4.4 Workload

4.4.1 Ratings of Workload Factors

Team leader and team member ratings of workload for each of six factors or sources of workload were subjected to a two-way ANOVA with information management and information availability as within-subjects effects. The six sources of workload examined in these analyses were mental, physical, and temporal demands, performance, effort, and frustration. The results of the analysis of team leader ratings of workload revealed a significant effect of information availability on team leader ratings of effort ($F[1,15] = 11.286$; $p < .005$) and frustration ($F[1,15] = 4.928$; $p < .05$). These findings are shown in Tables 9 and 10 and are depicted in Figures 19 and 20, respectively. The findings suggest that team leaders expended more effort and were more frustrated in conditions in which access to information on the HMD was restricted.

Table 9. ANOVA results of team leader ratings of effort

Source	SS	df	MS	F	*p*
Team	146704.6	7	20957.8	10.268	0.000
Availability	23036.13	1	23036.13	11.286	0.004
Management	2703.258	1	2703.258	1.324	0.268
Availability*Management	5344.672	1	5344.672	2.619	0.126
Order	10699.52	3	3566.508	1.747	0.200
Error	30615.64	15	2041.043		

Table 10. ANOVA results of team leader ratings of frustration

Source	SS	df	MS	F	*p*
Team	775842.1	7	110834.6	12.507	0.000
Availability	43672.83	1	43672.83	4.928	0.042
Management	5802.23	1	5802.23	0.655	0.431
Availability*Management	3738.684	1	3738.684	0.422	0.526
Order	27907.22	3	9302.407	1.050	0.399
Error	132927.9	15	8861.859		

The results of the analysis of team member ratings of frustration are shown in Table 11. Although the results that are illustrated in Figure 21 were technically not statistically significant ($F[1, 56] = 3.841$; $p = .055$), they are worthy of note and suggest the need for further study.

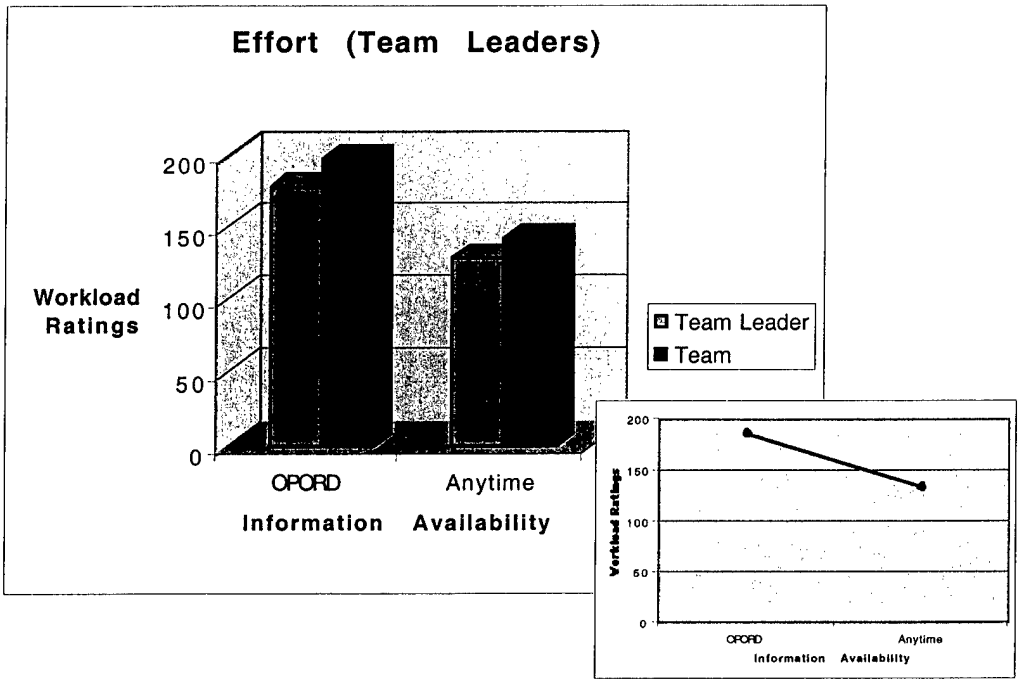

Figure 19. Main effect of information availability on team leader ratings of effort.

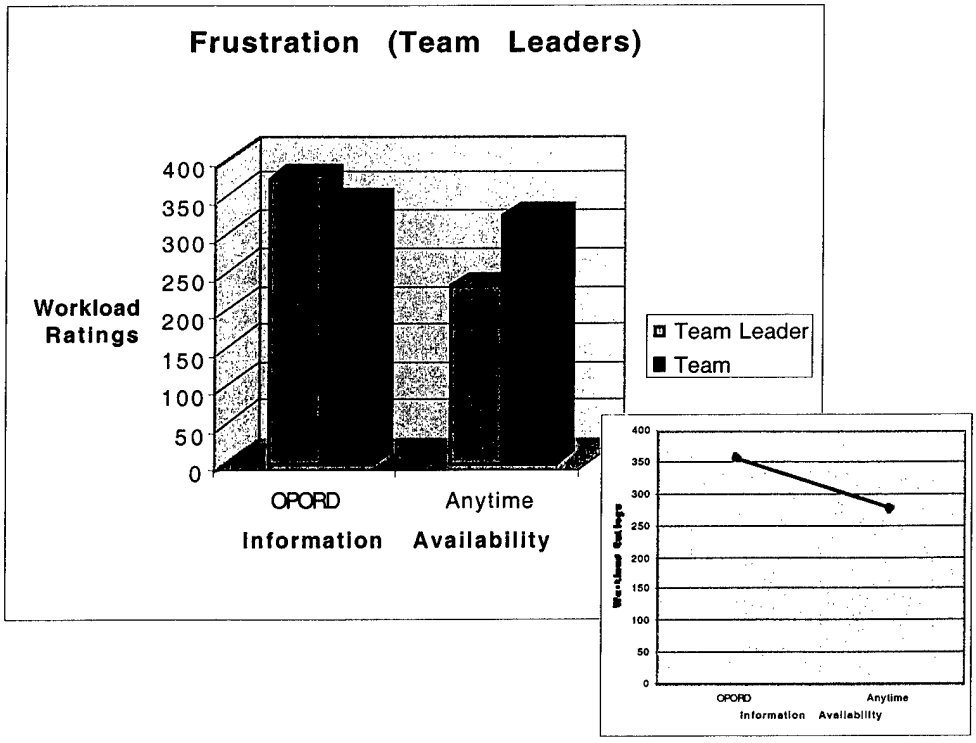

Figure 20. Main effect of information availability on team leader ratings of frustration.

Table 11. ANOVA results of team member ratings of frustration

Source	SS	df	MS	F	*p*
Team	1552797.40	23	67512.93	4.704	0.000
Availability	32446.67	1	32446.67	2.261	0.138
Management	43265.06	1	43265.06	3.014	0.088
Availability*Management	55124.86	1	55124.86	3.841	0.055
Order	48592.72	3	16197.57	1.129	0.345
Error	803745.7	56	14352.6		

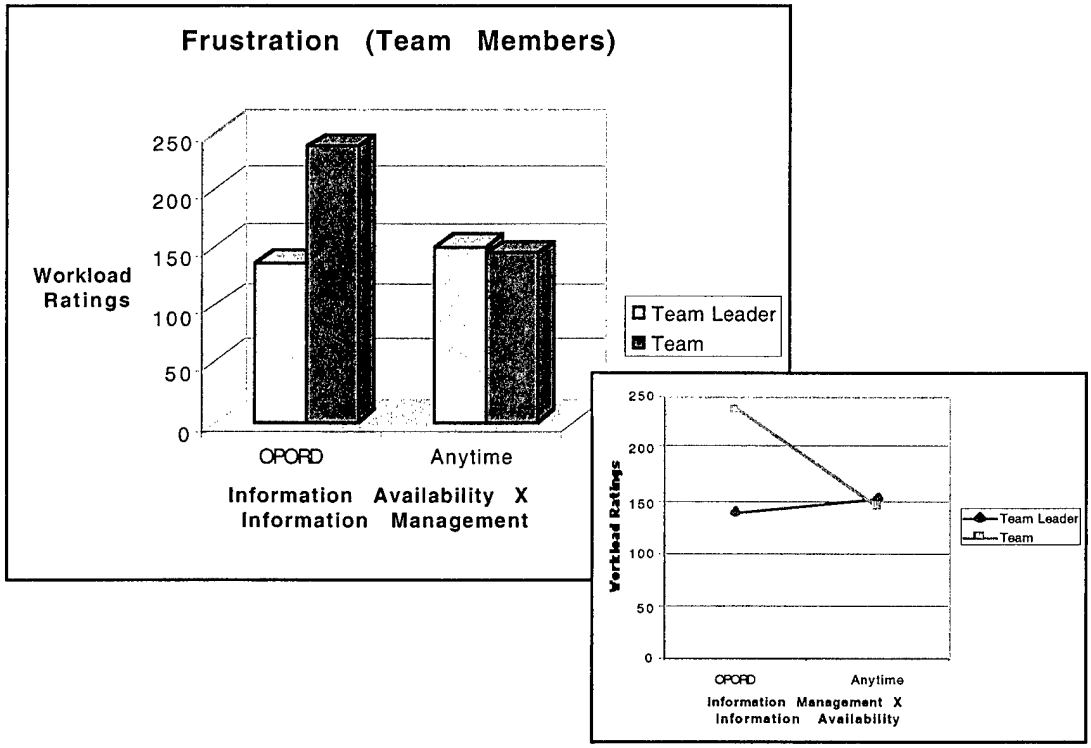

Figure 21. Team member ratings of frustration.

4.4.2 Overall Workload

Overall workload scores were computed for each team leader and team member from weighted ratings on each of the six workload factors. The overall workload scores of team leaders and team members were each subjected to a two-way ANOVA with information management and information availability as within-subjects effects.

The results of the analysis of the overall workload scores of team leaders are shown in Table 12. Although the results that are illustrated in Figure 22 are technically not statistically significant ($F[1,15] = 4.471$; $p = .052$), they are worthy of note and suggest the need for further study.

Table 12. ANOVA results of overall workload (team leaders)

Source	SS	df	MS	F	*p*
Team	11011.86	7	1573.123	20.017	0.000
Availability	351.346	1	351.346	4.471	0.052
Management	35.855	1	35.855	0.456	0.510
Availability*Management	32.12	1	32.12	0.409	0.532
Order	171.215	3	57.072	0.726	0.552
Error	1178.869	15	78.591		

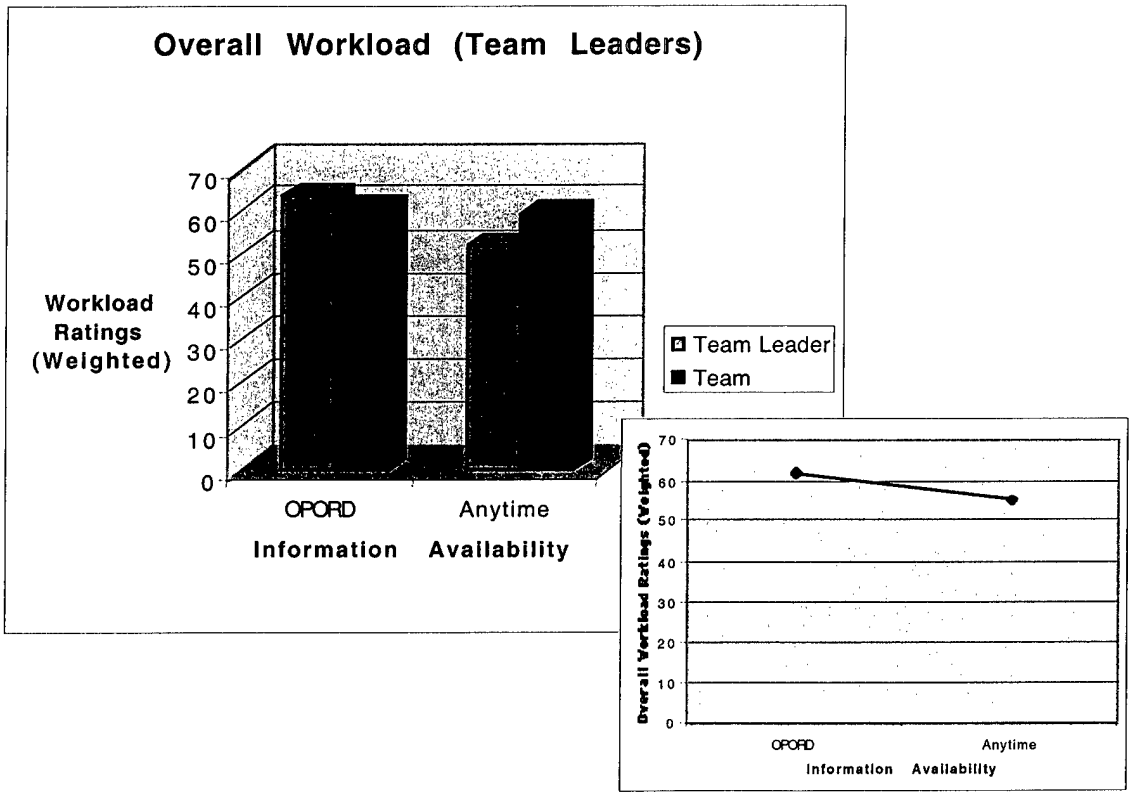

Figure 22. Overall workload experience of the team leaders.

The results of the analysis of the overall workload scores of team members are shown in Table 13. As indicated, the analysis revealed a significant effect of information management ($F[1, 56] = 8.210$; $p < .01$). As illustrated in Figure 23, this latter finding suggests that team member perceptions of workload were significantly higher when they provided support to the team leader in managing information.

Table 13. ANOVA results of overall workload (team members)

Source	SS	df	MS	F	*p*
Team	7320.033	7	1045.719	7.842	0.000
Team Member	13559.13	16	847.446	6.355	0.000
Availability	17.585	1	17.585	0.132	0.718
Management	1094.813	1	1094.813	8.21	0.006
Availability*Management	37.588	1	37.588	0.282	0.598
Order	601.831	3	200.61	1.504	0.223
Error	7467.473	56	133.348		

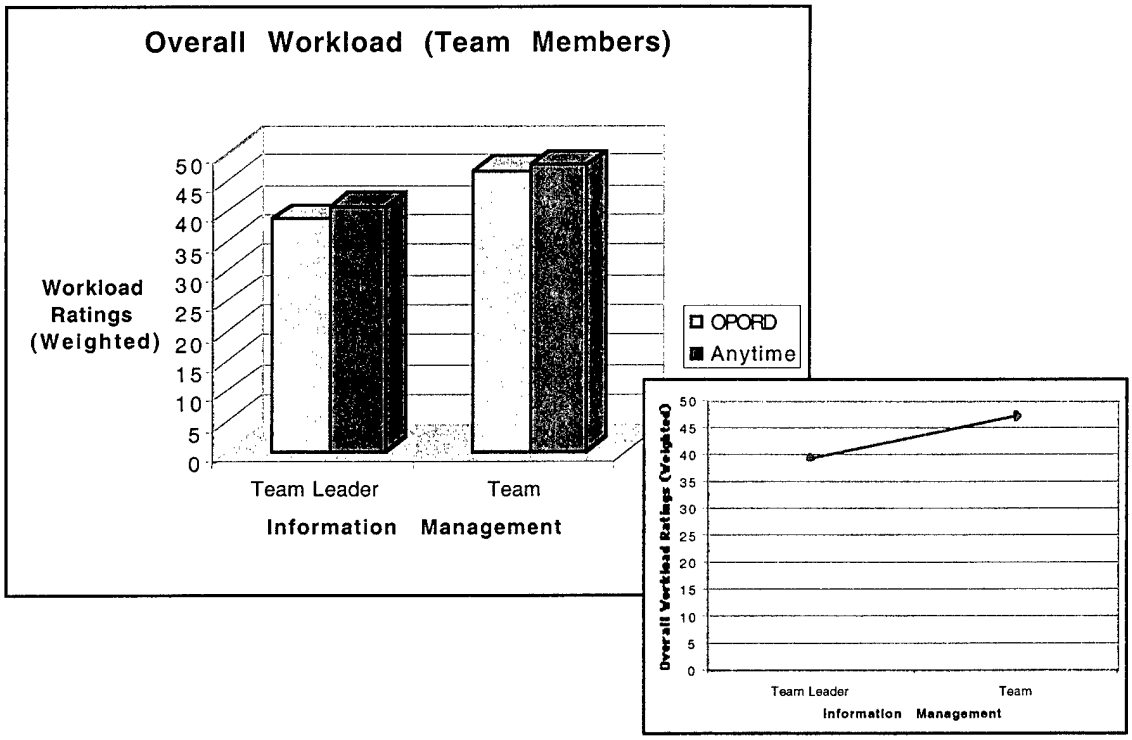

Figure 23. Main effect of information management on the overall workload experience of team members.

5. Discussion

Advances in communications and weapons technologies have increased the complexity of modern warfare and the decisions the soldier must make to successfully accomplish his mission. Although new sensor and display technologies offer to enhance soldier performance by providing him with more information about the battlefield, it is feared that such increases can

lead to cognitive overload. There are also concerns that increases in the quantity of information and the displays upon which this information is presented may compete for the soldier's attention, reduce his awareness of the situation immediately around him, and conflict with his performance of other critical tasks (National Research Council, 1997).

The primary objective of this field study was to examine the effects of information availability and information management on SA and mission performance of dismounted fire teams. It was hypothesized that the availability of information to team leaders on an HMD would enhance their ability to recall information about the battlefield and their global SA by increasing the frequency of information review. Navigational efficiency was also expected to improve as a function of the frequency of updates of team position. On the other hand, the attentional demands imposed on team leaders when they view information presented on the HMD were expected to reduce their ability to detect wooden silhouettes of personnel that had been positioned along the course. Local SA of the team as a whole, however, was not expected to degrade.

The results of the study indicated that in missions in which access to information on the HMD was limited, team leaders perceived that they expended more effort and were more frustrated. However, in missions in which information could be accessed at any time on the HMD, team leader awareness of the local situation, as measured by the number of targets that the team leaders detected along the course, declined significantly. Local SA of the team as a whole was not significantly affected by the availability of information to the team leader on the HMD or team involvement in information management. From this, however, it should not be concluded that the HMD used in the present study was the sole contributor to losses in local SA. In a previous study by Glumm et al. (1998), participants claimed that the HMD was not any more distracting than their conventional hand-held displays. Certainly, any display that obstructs or limits the field of view can cause an object or event that occurs within the area that is obscured to go undetected. However, there is also evidence that some objects or events that are fully visible within the same display may also go unnoticed (Mack & Rock, 1998; Most et al., 2001). Soldier awareness of the situation beyond the display, both locally and globally, will be affected by a number of factors. Among these factors are the amount of time and level of attention directed to the display. The more cognitively immersed the soldier becomes in the displayed information, the less time and attention available for other tasks, particularly those that involve the same mental resources. In this study, the different types of information were quickly and easily accessed via a keypad with labeled pushbuttons, but the controller used by the future soldier will be more complex. As the time required to access information increases along with the complexity of the information display, less time will be available to attend to the immediate environment.

In this study, overall workload scores of team members were found to be significantly higher in conditions in which team members provided information management support, but team participation in managing information was not found to produce a significant improvement in global SA or overall mission performance.

Contrary to hypothesis and to previous findings of Glumm et al. (1998), the availability of positional information on the HMD did not appear to have a significant effect on navigational efficiency. This latter finding may be attributed to the tendency of the "point man" who preceded the rest of the team to rely less on navigational information provided by the hand-held GPS and more on tracking a path that had been worn in some sections of the course after successive runs. Although performance of some mission tasks appeared to be influenced by levels of information availability, measures of overall mission performance compiled from these data were not. Good performance of one task may have also been offset by poor performance of another.

Differences in performance between levels of information availability on the two measures of global SA were technically not statistically significant. Nevertheless, the reader should note that performance of the two measures of global SA appeared to take different directions when information was available at any time on the HMD. Threat recognition performance appeared to increase, and the accuracy of responses to probe questions appeared to decline. This anomaly may have been influenced by differences between the two measures of SA and by the experimental situation.

For example, the threat recognition task required a dedicated precision when the position of the team was tracked with respect to threats. Recognizing that the team was within a specified 20- to 50-meter range of a threat required frequent updates of team location and may have been more sensitive to the availability of navigational information which was accessed more often than other types of tactical data. In addition to frequent updates of team position, correct responses to probe questions also required knowledge of other kinds of information. This information included the types of friendly or enemy units, their positions to the left or right of the designated path, the call signs of friendly units, and available fire support. Unless this information was studied before or during the mission, the probability of answering the probe questions correctly was reduced to chance. In this experiment, the teams may have spent less time and attention studying these tactical details before the mission when they knew that during the mission, information could be accessed at any time. During the mission, however, other task demands and reduced opportunity to review the different types of information may have decreased the potential for accurate recall. Although competing demands are also expected to affect information access in the actual battlefield, it is unlikely that the soldier would neglect to study important tactical details before the mission. Implied here is the danger of relying on information to be available during the mission.

In summary, it cannot be concluded from the results of this study that the availability of information on an HMD or team support in managing this information will enhance or degrade global SA. In the battlefield, some information will need to be accessed more frequently than other information, and reductions in the availability of information may have more of an effect on one task than on another. The findings of this study emphasize the importance of designing displays and controls to allow quick and easy access to mission-critical information that may

change frequently. Also suggested is care in the selection and analysis of measures of SA to reliably assess the value of any proposed improvements in the system.

6. Conclusions and Recommendations

In this study, increased availability of information on an HMD significantly reduced awareness of the local situation with no statistically significant improvement in the awareness of the situation in the larger battlefield. These findings emphasize the importance of control-display design in the successful exploitation of advances in information technology. More information about the battlefield is helpful to soldiers if they can use this information to their advantage. Increases in the quantity of information may not necessarily yield a greater awareness of the situation in the larger battlefield. Rather, the more time and attention that soldiers dedicate to the information display, the greater the risk of losses in soldiers' awareness of more immediate hazards.

Designers of tactical displays and input devices for the soldier must remain aware that the physical and psychological stresses to which soldiers are exposed compound difficulties in the operation of complex systems. They must recognize that the capabilities of the soldier do not keep pace with advances in technology and that advanced technology does not always provide a solution. If information technology is to enhance soldier performance, the research and development community must focus on minimizing the time required for soldiers to access, interpret, and act upon information that is critical to mission performance and survival.

In this study, the level of information management support provided to the team leaders by their team members was not found to have a significant effect on team performance.

However, as the complexity of the battlefield increases along with the quantity and diversity of information available to soldiers, team support in managing information will become increasingly important to maintaining global and local SA.

However, not all team leaders are inclined to share information with their team members, nor are all team leaders skilled in identifying team member capabilities and effectively using the resources available within their team. Future research is needed to examine information sharing, leader skills, and training needs to maximize management of team resources.

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Appendix A: Survey and Results

Demographic Questionnaire

Instructions: Please answer each of the following questions. All the information that you provide will remain strictly confidential. Neither you nor your unit will be identified in any report of the results of this questionnaire.

Company/Unit: _____ **Location:** _____

Rank: _____

Age: _____ years

Military Occupational Specialty (MOS): _____

Time in Service: _____years _____months

Time in MOS: _____years _____months

Training *(Please check all that apply)*

PLDC	[ ]
BNCOC	[ ]
ANCOC	[ ]
Battle Staff	[ ]
Other *(Please specify)*	_____
	_____
	_____

Positions Held *(Check all that apply):*

Rifleman	[ ]	Fire team leader	[ ]	Operations NCO	[ ]
Automatic rifleman	[ ]	Ammo chief	[ ]	Assistant ops NCO	[ ]
Machine gunner	[ ]	Squad leader	[ ]	Liaison NCO	[ ]
Dragon/Javelin Gunner	[ ]	Platoon sergeant	[ ]	Intelligence NCO	[ ]
Grenadier	[ ]	Team leader	[ ]	First sergeant	[ ]
				Other *(Please specify):*	_____
					_____

Combat Experience

Geographic Area *(Check all that apply)*	Duration of Tour *(Circle either Yes or No)*	Did you see combat?		**If "Yes"** During Combat Duty Position
Granada [ ]	_____years ____months	Yes	No	_____
Somalia [ ]	_____years ____months	Yes	No	_____
Panama [ ]	_____years ____months	Yes	No	_____
Kuwait [ ]	_____years ____months	Yes	No	_____
Iraq [ ]	_____years ____months	Yes	No	_____
Bosnia [ ]	_____years ____months	Yes	No	_____
Haiti [ ]	_____years ____months	Yes	No	_____
Other *(Please specify)*				
_____	_____years ____months	Yes	No	_____
_____	_____years ____months	Yes	No	_____
_____	_____years ____months	Yes	No	_____

What is the purpose of this questionnaire?

In the future battlefield you will have access to much more information than you have access to now. Some of this information will be more important to your effectiveness in combat and the success of your mission than other information. Our goal is to make sure you can easily access the information you need -- when you need it.

This questionnaire is a first step in research to measure the effects of information availability and accessibility on mission success.

We understand that your information needs depend on your mission. Therefore we have provided a description of a mission to provide the context on which you will base your answers. It is a Movement to Contact and Attack Mission scenario that includes the likelihood of most threats.

Instructions

This questionnaire has two parts.

In Part 1 we ask: **When the mission is over**, how do you know that you have been successful in performing your mission -- that is, what are your **measures** of success?

We include a list of measures of success for you to choose from. We also provide space at the end of the list for you to add other measures that you believe are important indicators of success.

First: Check (√) all those measures that you think are indicators of mission success.

Second: Check (√) the 10 best indicators of mission success.

Third: Rate each of these 10 indicators on how good an indicator of success it is from "good" to "excellent."

In Part 2 we ask: **Based on the attached mission scenario**, what information do you need and when do you need to access this information in order to achieve these measures of success?

We include a list of types of information for you to choose from. We also provide space at the end of the list for you to add other types of information that you believe are important to achieve your 10 measures of success.

First: Check (√) the types of information you think you need to achieve the 10 measures of success you selected in Part 1.

Second: Check (√) the **10** types of information that are **most** critical to mission success -- information you just can't do without if this mission is to work.

Third: Tell us when you need to receive **each** of these **10 types of information** by checking (√) ONE of six options. These options are: (1) At Op Ord and only when info changes (2) At each waypoint (3) Every __ meters (4) Every __ minutes (5) After the mission (6) Other _____. If you choose options 3 or 4, make sure to write in the number of meters or minutes in the [___]. If you choose Option 6 ("Other"), make sure to write in another option.

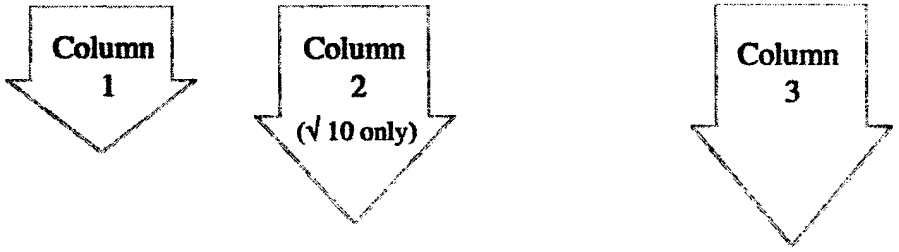
PLEASE read the following mission scenario carefully. You may then proceed to Part 1 and then to Part 2.

PART 1. **After the mission is over,** how do you know that you have been successful in performing your mission?

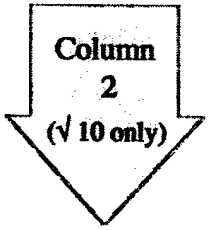
(a) In Column 1, check all those measures that you believe are indicators of success. (Add other indicators, as desired, in the space provided at the end of the list).

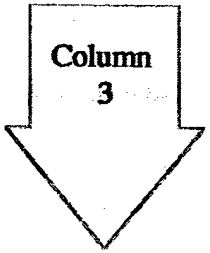
(b) In Column 2, check the **10** measures that you believe are the **best** indicators of success.

(c) In Column 3, for each of the **10** measures you checked in Column 2, rate how **good** an indicator of success each is by placing an "X" on the scale provided.



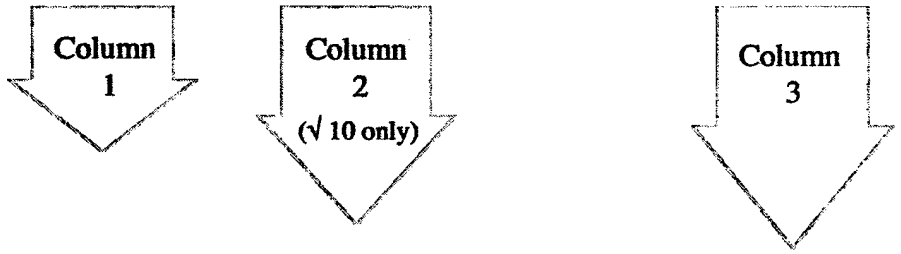
Mission Success Indicators			Average (Good) Indicator	Above Average Indicator	Excellent (Best) Indicator
Confident in equipment	[ ]	[ ]			
Confident in unit cohesion	[ ]	[ ]			
Maintained commo up the chain of command	[ ]	[ ]			
Maintained commo down the chain of command	[ ]	[ ]			
Followed orders	[ ]	[ ]			
Detected and avoided minefields	[ ]	[ ]			





Mission Success Indicators (continued)

			Average (Good) Indicator	Above Average Indicator	Excellent (Best) Indicator
Detected and avoided ambushes	[ ]	[ ]			
Detected and destroyed all enemy bunkers	[ ]	[ ]			
Negotiated and avoided all terrain obstacles	[ ]	[ ]			
Bypassed other danger areas	[ ]	[ ]			
Reached waypoints on time	[ ]	[ ]			
Quickly and accurately acquired targets	[ ]	[ ]			
Effectively handed off targets	[ ]	[ ]			
Destroyed enemy equipment	[ ]	[ ]			
Received adequate supporting fires	[ ]	[ ]			
Seized and occupied terrain	[ ]	[ ]			
Enemy retreated	[ ]	[ ]			
All the men in my unit survived	[ ]	[ ]			
No injuries in unit	[ ]	[ ]			
No incidents of fratracide	[ ]	[ ]			
All the enemy were destroyed	[ ]	[ ]			
All the enemy were captured	[ ]	[ ]			
No civilian casualties	[ ]	[ ]			
Did not run out of ammunition	[ ]	[ ]			



Mission Success Indicators (continued)

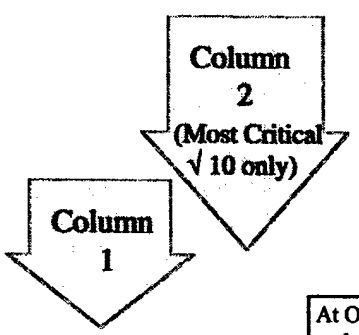
	Column 1	Column 2 (√ 10 only)	Average (Good) Indicator	Above Average Indicator	Excellent (Best) Indicator
Did not run out of water	[ ]	[ ]			
Did not run out of rations	[ ]	[ ]			
Did not lose any equipment	[ ]	[ ]			
Completed mission on time	[ ]	[ ]			
Little to no fatigue	[ ]	[ ]			
Physically/mentally prepared for next mission	[ ]	[ ]			
Other (please specify): _____	[ ]	[ ]			
_____	[ ]	[ ]			
_____	[ ]	[ ]			

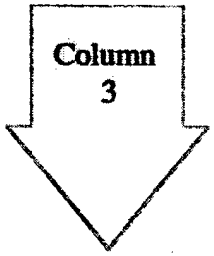
PART 2. **Based on the attached mission scenario,** what information items do you need and when do you need this information to achieve these measures of success?

(a) In Column 1, check the types of information that you need to achieve the **10** measures of success you selected in Part 1. (Add other types of information as desired in the space at the end of the list).

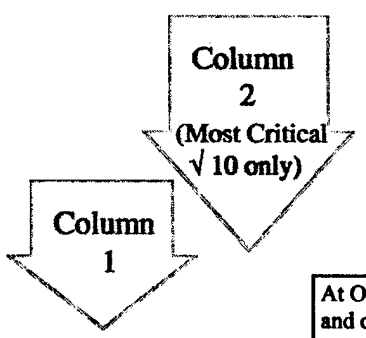
(b) In Column 2, check the **10** types of information that are **most** critical to mission success -- information that you could NOT do without if the mission is to work.

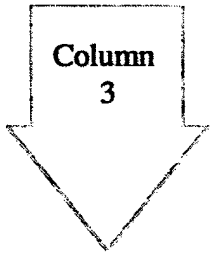
(c) In Column 3, indicate when you need **each of these 10 types of information** by checking (√) one of the six options provided. (Check ONLY **one** option for each type of information. If you select either "Every ___ meters" or "Every___ minutes" be sure to write in the number of meters or minutes in the [__] under that option. If you check "Other" make sure to specify another option in the space provided).





Information Items	Column 1	Column 2 (Most Critical √ 10 only)	At Op Ord/ and only when info changes	At each Waypoint	Every __ meters	Every __ minutes	After mission	Other *(please specify)*
Route of march	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Terrain profile and obstacles	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____

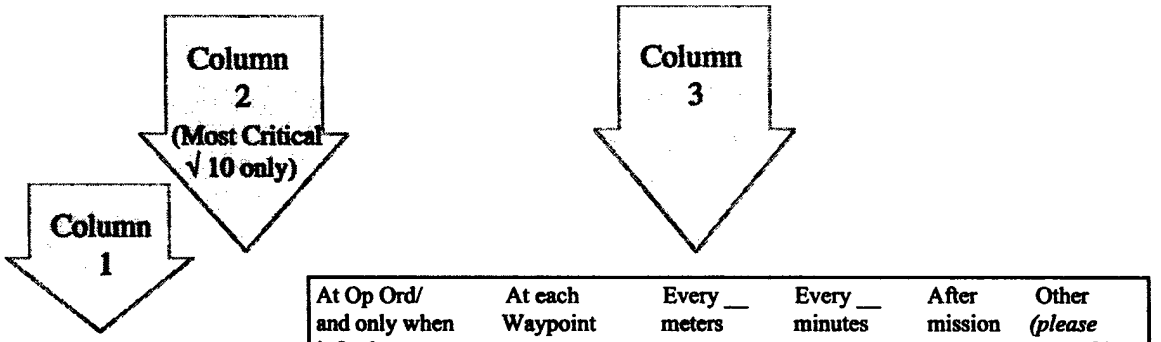




	At Op Ord/ and only when info changes	At each Waypoint	Every __ meters	Every __ minutes	After mission	Other *(please specify)*

Information Items (continued)

Weather	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Time required to achieve waypoints	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Time and distance to objectives	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Time to complete mission	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Locations and types of targets	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Type of NBC threat	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Location of enemy units	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Speed and direction of movement of enemy units	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Type of enemy weapons/equipment	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Location of mine fields	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Location of enemy bunkers	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Location of possible ambushes	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Your unit position	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Your own position	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____



Information Items (continued)

Location of friendly units	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Location of adjacent friendly unit	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Speed and direction of movement of friendly units	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Available fire support (e.g. air, artillery)	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Call signs and frequencies of supporting units	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Location of civilians	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Current ammunition status of your element	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Current water status of your element	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Current rations status of your element	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Location and time of next resupply	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Unit relief/time of arrival	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
Other (please specify): _____	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
_____	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____
_____	[ ]	[ ]	[ ]	[ ]	[___]	[___]	[ ]	____

Thank you!

Of the 30 mission success indicators listed in the survey questionnaire, each soldier selected the 10 that he believed to be the best indicators of mission success. The number of times each success indicator was selected was calculated, and the 10 indicators selected most often were chosen for focus in the present study.[2]

Table A-1. Survey results: Mission success indicators

Mission Success Indicator		Frequency of Selection (%) (N = 42)
1.	Maintained communication up the chain of command	.7368
2.	Did not run out of ammunition	.7368
3.	All the enemy were destroyed	.6842
4.	All the men in my unit survived	.6842
5.	Maintained communication down the chain of command	.6316
6.	Seized and occupied terrain	.5789
7.	No incidents of fratricide	.5263
8.	Received adequate supporting fires	.5263
9.	Physically and mentally prepared for next mission	.5263
10.	Reached waypoints on time	.4211
11.	Quickly and accurately acquired targets	.4211
12.	Detected and destroyed all enemy bunkers	.3684
13.	Followed orders	.3158
14.	Confident in unit cohesion	.2632
15.	No injuries in unit	.2632
16.	Completed mission on time	.2632
17.	Confident in equipment	.2105
18.	Destroyed enemy equipment	.2105
19.	Bypassed other danger areas	.1579
20.	Enemy retreated	.1579
21.	Detected and avoided ambushes	.1579
22.	All the enemy were captured	.1579
23.	No civilian casualties	.1579
24.	Did not run out of water	.1579
25.	Did not lose any equipment	.1579
26.	Detected and avoided minefields	.1053
27.	Effectively handed off targets	.1053
28.	Did not run out of rations	.0000
29.	Negotiated and avoided all terrain obstacles	5.263E-02
30.	Little to no fatigue	5.263E-02

[2]Eleven (11) rather than 10 indicators were selected for the study, given that mission indicators 10 and 11 were chosen an equal number of times.

Table A-2. Survey results: Information requirements

Information Requirements	Frequency of Selection (%) (N = 42)
1. Call signs and frequencies of supporting units	.7500
2. Available fire support	.7000
3. Locations and types of targets	.6500*
4. Current ammunition status of your element	.6000
5. Location of possible ambushes	.5500
6. Type of enemy weapons and equipment	.5500
7. Location of enemy units	.5500
8. Type of NBC threat	.5500
9. Time to complete mission	.5500
10. Location of friendly units	.5000
11. Location of mine fields	.5000
12. Time and distance to objectives	.4500
13. Location of adjacent friendly unit	.4500
14. Your own position	.4000
15. Route of march	.4000
16. Location and time of next resupply	.3500*
17. Terrain profile and obstacles	.3500*
18. Your unit position	.3500
19. Location of enemy bunkers	.3000*
20. Speed and direction of movement of enemy units	2500*
21. Weather	.2000*
22. Time required to achieve waypoints	.2000
23. Current rations status of your element	.1500*
24. Speed and direction of movement of friendly units	.1500*
25. Unit relief/time of arrival	.1500*
26. Current water status of your element	1.000E-02*
27. Location of civilians	5.000E-01*

* Information not presented

Table A-3. Survey results: Information access requirements

Information Requirements	Access Requirements
1. Call signs and frequencies of supporting units	At OPORD & when info changes
2. Available fire support	At OPORD & when info changes
3. Locations and types of targets	At OPORD & when info changes
4. Current ammunition status of your element	At OPORD & when info changes, and at each waypoint
5. Location of possible ambushes	At OPORD & when info changes
6. Type of enemy weapons and equipment	At OPORD & when info changes
7. Location of enemy units	At OPORD & when info changes
8. Type of NBC threat	At OPORD & when info changes
9. Time to complete mission	At OPORD & when info changes
10. Location of friendly units	At OPORD & when info changes
11. Location of minefields	At OPORD & when info changes
12. Time and distance to objectives	At OPORD & when info changes
13. Location of adjacent friendly unit	At OPORD & when info changes
14. Your own position	At OPORD & when info changes
15. Route of march	At OPORD & when info changes
16. Location and time of next resupply	At OPORD & when info changes and after mission
17. Terrain profile and obstacles	At OPORD & when info changes
18. Your unit position	At OPORD & when info changes
19. Location of enemy bunkers	At OPORD & when info changes
20. Speed and direction of movement of enemy units	At OPORD & when info changes
21. Weather	At OPORD & when info changes
22. Time required to achieve waypoints	At OPORD & when info changes
23. Current rations status of your element	At OPORD & when info changes and after mission
24. Speed and direction of movement of friendly units	At OPORD & when info changes
25. Unit relief/time of arrival	At OPORD & when info changes and after mission
26. Current water status of your element	At OPORD & when info changes and after mission
27. Location of civilians	At OPORD & when info changes

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Appendix B: Situational Self-Efficacy (SSE) Scale

SSE

On a scale from 1 to 10, how confident are you in your ability to successfully complete your upcoming mission?

Please circle one of the numbers below.

1	2	3	4	5	6	7	8	9	10
Not at all confident								**Extremely confident**	

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Appendix C: Demographic Questionnaire

Please answer the following questions. The information you provide will be kept CONFIDENTIAL.

1. Name: _____
   Last First Middle Initial
2. Age: _____
3. Rank: _____
4. Military Occupational Specialty (MOS): _____
5. Time in service: _____years _____ months
6. Time in grade: _____years _____ months
7. Time in MOS: _____years _____ months
8. Are you left- or right-handed?

   Left-Handed [ ] Right-Handed [ ]

9. Do you wear eyeglasses or contacts?

   Yes [ ] No [ ]

10. Have you ever worn a head- or helmet-mounted display (HMD)?

    Yes [ ] No [ ]

11. How would you rate your ability to use a lensatic compass?

Excellent	[ ]
Good	[ ]
Neither Good nor Bad	[ ]
Fair	[ ]
Poor	[ ]
Never used one	[ ]

12. How would you rate your ability to use a hand-held Global Positioning System (GPS)?

Excellent	[ ]
Good	[ ]
Neither Good nor Bad	[ ]

Fair	[ ]
Poor	[ ]
Never Used One	[ ]

13. Generally, how would you rate your land navigation skills?

Excellent	[ ]
Good	[ ]
Neither Good nor Bad	[ ]
Fair	[ ]
Poor	[ ]

14. If you were to add it up, about how much time have you spent as a fire team leader prior to this study?

Years _____ Months _____ Other? _____

15. Prior to this study, have you worked as a team with any of the other members of the team with whom you will be working with in this study?

Yes [ ] No [ ]

If you answered "Yes" to Question #15, please answer Questions #15a through 15c.

a. How many members of the present team have you worked with before as a team?

One [ ] Two [ ] Three [ ]

b. On the average, about how much time have you worked with them as a team?

Years _____ Months _____ Other? _____

c. In what capacity did you work with them?

Team Leader [ ] Team Member [ ] Both [ ]

Appendix D: Environmental Symptoms Questionnaire (ESQ)

ENVIRONMENTAL SYMPTOMS OUESTIONNAIRE-R

INSTRUCTIONS: Indicate whether you have any of the symptoms below by circling the appropriate number for EACH item. Answer all items according to how you feel RIGHT NOW. (Note: It is possible for you to have none of the symptoms below. However, since it is important that you read every statement, respond to each statement individually.)

		NOT AT ALL	SLIGHT	SOMEWHAT	MODERATE	QUITE A BIT	EXTREME
1.	I have a headache	0	1	2	3	4	5
2.	My head is throbbing	0	1	2	3	4	5
3.	I feel light headed	0	1	2	3	4	5
4.	I feel faint	0	1	2	3	4	5
5.	I have ringing in my ears	0	1	2	3	4	5
6.	It is hard to breathe	0	1	2	3	4	5
7.	My breathing seems fast	0	1	2	3	4	5
8.	My breathing seems irregular	0	1	2	3	4	5
9.	I feel nauseous	0	1	2	3	4	5
10.	I feel stomach pressure	0	1	2	3	4	5
11.	I have stomach pains	0	1	2	3	4	5
12.	My stomach is upset	0	1	2	3	4	5
13.	I have diarrhea	0	1	2	3	4	5
14.	I have constipation	0	1	2	3	4	5
15.	I have to urinate frequently	0	1	2	3	4	5
16.	My heartbeat seems fast	0	1	2	3	4	5
17.	My heart is pounding	0	1	2	3	4	5
18.	My heartbeat seems irregular	0	1	2	3	4	5
19.	My muscles are tense	0	1	2	3	4	5
20.	My muscles ache	0	1	2	3	4	5
21.	I have back pains	0	1	2	3	4	5
22.	I have chest pains	0	1	2	3	4	5
23.	I feel weak	0	1	2	3	4	5
24.	My hands feel cold	0	1	2	3	4	5
25.	I feel chilly	0	1	2	3	4	5
26.	I am shivering	0	1	2	3	4	5

		NOT AT ALL	SLIGHT	SOMEWHAT	MODERATE	QUITE A BIT	EXTREME
27.	I feel warm	0	1	2	3	4	5
28.	My hands are sweaty	0	1	2	3	4	5
29.	I am sweating	0	1	2	3	4	5
30.	My skin feels sensitive	0	1	2	3	4	5
31.	My eyes feels irritated	0	1	2	3	4	5
32.	My eyes are watery	0	1	2	3	4	5
33.	My vision is blurry	0	1	2	3	4	5
34.	My nose is blocked	0	1	2	3	4	5
35.	My nose is running	0	1	2	3	4	5
36.	My nose is bleeding	0	1	2	3	4	5
37.	My ears are blocked	0	1	2	3	4	5
38.	My ears ache	0	1	2	3	4	5
39.	I can't hear well	0	1	2	3	4	5
40.	My mouth is dry	0	1	2	3	4	5
41.	My throat is sore	0	1	2	3	4	5
42.	My sense of balance is off	0	1	2	3	4	5
43.	I feel clumsy	0	1	2	3	4	5
44.	I feel tired	0	1	2	3	4	5
45.	I feel sleepy	0	1	2	3	4	5
46.	I have trouble concentrating	0	1	2	3	4	5
47.	I have trouble remembering things	0	1	2	3	4	5
48.	I feel worried about something	0	1	2	3	4	5
49.	I feel bored	0	1	2	3	4	5
50.	I feel irritable	0	1	2	3	4	5
51.	I have trouble sleeping last night	0	1	2	3	4	5
52.	I am happy	0	1	2	3	4	5
53.	I feel well	0	1	2	3	4	5
54.	My thinking is clear	0	1	2	3	4	5
55.	I have trouble understanding instructions	0	1	2	3	4	5
56.	Other _____	0	1	2	3	4	5

INSTRUCTIONS: Indicate whether you had any of the symptoms below during the exercise you just completed by circling the appropriate number for EACH item. Answer all items. (Note: It is possible for you to have none of the symptoms below. However, since it is important that you read every statement, respond to each statement individually.)

		NOT AT ALL	SLIGHT	SOMEWHAT	MODERATE	QUITE A BIT	EXTREME
1.	I had a headache	0	1	2	3	4	5
2.	My head was throbbing	0	1	2	3	4	5
3.	I felt light headed	0	1	2	3	4	5
4.	I felt faint	0	1	2	3	4	5
5.	I had ringing in my ears	0	1	2	3	4	5
6.	It was hard to breathe	0	1	2	3	4	5
7.	My breathing seemed fast	0	1	2	3	4	5
8.	My breathing seemed irregular	0	1	2	3	4	5
9.	I felt nauseous	0	1	2	3	4	5
10.	I felt stomach pressure	0	1	2	3	4	5
11.	I had stomach pains	0	1	2	3	4	5
12.	My stomach was upset	0	1	2	3	4	5
13.	I had diarrhea	0	1	2	3	4	5
14.	I had constipation	0	1	2	3	4	5
15.	I had to urinate frequently	0	1	2	3	4	5
16.	My heartbeat seemed fast	0	1	2	3	4	5
17.	My heart was pounding	0	1	2	3	4	5
18.	My heartbeat seemed irregular	0	1	2	3	4	5
19.	My muscles were tense	0	1	2	3	4	5
20.	My muscles ached	0	1	2	3	4	5
21.	I had back pains	0	1	2	3	4	5
22.	I had chest pains	0	1	2	3	4	5
23.	I felt weak	0	1	2	3	4	5
24.	My hands felt cold	0	1	2	3	4	5
25.	I felt chilly	0	1	2	3	4	5
26.	I was shivering	0	1	2	3	4	5
27.	I felt warm	0	1	2	3	4	5
28.	My hands were sweaty	0	1	2	3	4	5
29.	I was sweating	0	1	2	3	4	5
30.	My skin felt sensitive	0	1	2	3	4	5
31.	My eyes felt irritated	0	1	2	3	4	5

		NOT AT ALL	SLIGHT	SOMEWHAT	MODERATE	QUITE A BIT	EXTREME
32.	My eyes were watery	0	1	2	3	4	5
33.	My vision was blurry	0	1	2	3	4	5
34.	My nose was blocked	0	1	2	3	4	5
35.	My nose was running	0	1	2	3	4	5
36.	My nose was bleeding	0	1	2	3	4	5
37.	My ears were blocked	0	1	2	3	4	5
38.	My ears ached	0	1	2	3	4	5
39.	I couldn't hear well	0	1	2	3	4	5
40.	My mouth was dry	0	1	2	3	4	5
41.	My throat was sore	0	1	2	3	4	5
42.	My sense of balance was off	0	1	2	3	4	5
43.	I felt clumsy	0	1	2	3	4	5
44.	I felt tired	0	1	2	3	4	5
45.	I felt sleepy	0	1	2	3	4	5
46.	I had trouble concentrating	0	1	2	3	4	5
47.	I had trouble remembering things	0	1	2	3	4	5
48.	I felt worried about something	0	1	2	3	4	5
49.	I felt bored	0	1	2	3	4	5
50.	I felt irritable	0	1	2	3	4	5
51.	I had trouble sleeping last night	0	1	2	3	4	5
52.	I was happy	0	1	2	3	4	5
53.	I felt well	0	1	2	3	4	5
54.	My thinking was clear	0	1	2	3	4	5
55.	I had trouble understanding instructions	0	1	2	3	4	5
56.	Other _____	0	1	2	3	4	5

Appendix E: National Aeronautics and Space Administration-Task Load Index (NASA-TLX)

RATING SCALE DEFINITIONS

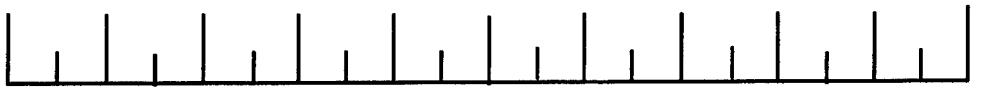
Title	End Points	Descriptions
MENTAL DEMAND	Low/High	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	Low/High	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	Low/High	How much time pressure did you feel due to the rate or pace at which the task or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	Perfect/Failure	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
EFFORT	Low/High	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION LEVEL	Low/High	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Effort or **Performance**	**Temporal Demand** or **Frustration**
Temporal Demand or **Effort**	**Physical Demand** or **Frustration**
Performance or **Frustration**	**Physical Demand** or **Temporal Demand**
Physical Demand or **Performance**	**Temporal Demand** or **Mental Demand**

Frustration or **Effort**	**Performance** or **Mental Demand**
Performance or **Temporal Demand**	**Mental Demand** or **Effort**
Mental Demand or **Physical Demand**	**Effort** or **Physical Demand**
Frustration or **Mental Demand**	

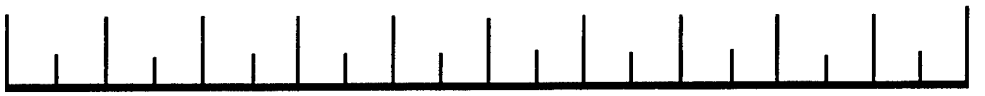
RATING SCALE SHEET

MENTAL DEMAND



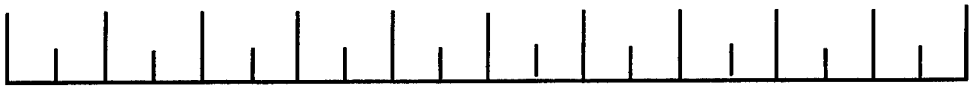
Low **High**

PHYSICAL DEMAND



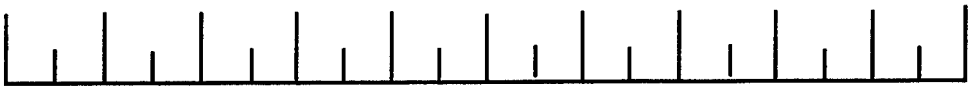
Low **High**

TEMPORAL DEMAND



Low **High**

PERFORMANCE



Good **Poor**

EFFORT

Low **High**

FRUSTRATION

Low **High**

Appendix F: Post-Run and Post-Test Questionnaires

Based on the mission you ***just*** completed, please answer each of the following questions by circling the response that best represents your opinion.

Table F-1. Team member questionnaire (post run)

(a) Our team easily detected the targets in the woods.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(b) Our team always knew where we were on the course.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(c) Our team always knew where we were in relation to other units and threats.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(d) We had good communications within our team.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(e) I had just the right amount of information needed to support our team's mission.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(f) I had just the right kinds of information needed to support our team's mission.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(g) More of the information provided to the fire team leader on the HMD should have been provided to the team members.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(h) I am confident that our team successfully performed the mission.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

Please use the space below to add any additional comments you might have.

Thank you!

Based on the mission you ***just*** completed, please answer each of the following questions by circling the response that best represents your opinion.

Table F-2. Team leader questionnaire (post run)

(a) It was easy to navigate through the course with the information provided on the HMD.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(b) It was easy to navigate through the course using the standard navigation equipment.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(c) I had all the right kinds of information needed to perform my mission.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(d) I had too much information.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(e) The information on the HMD was available when I needed it.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(f) It was easy to remember the information on the HMD.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(g) It was easy to remember the information on the paper map.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(h) I was always aware of what was going on immediately around me when I was using the HMD.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(i) I often detected targets in the woods before my team members.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(j) I always knew where we were on the course.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(k) I always knew where we were in relation to other friendly and enemy units.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(l) I always knew where we were in relation to threats.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(m) I am confident that our team successfully performed the mission.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

Please use the space below to add any additional comments you might have.

Thank you!

Based on your ***overall*** experience during this field study, please answer each of the following questions by circling the response that best represents your opinion.

Table F-3. Team leader questionnaire (post test)

(a) The paper map was easy to read.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(b) The information presented on the HMD was easy to read.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(c) It was easy to understand the information on the HMD.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(d) It was easy to understand the information on the paper map.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(e) I remained aware of what was going on immediately around me when I was reading the HMD.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(f) I remained aware of what was going on immediately around me when I was reading the paper map.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(g) I could read the HMD while walking.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(h) I could read the standard navigation equipment while walking.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(i) The HMD was difficult to adjust.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(j) The HMD was too heavy.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(k) The HMD caused eye strain.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(l) The HMD caused motion sickness.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(m) The HMD gave me a headache.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(n) The information provided on the HMD was well organized.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

(o) Increasing the frequency at which I could access information on the HMD helped me perform my mission better.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

Please use the space below to add any additional comments you might have.

Thank you!

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13. ABSTRACT *(Maximum 200 words)*

This field study examined the effects of information availability on a helmet-mounted display (HMD) and team support in managing this information about global and local situational awareness (SA), performance, and perceptions of workload. During the investigation, Marine Corps fire teams performed missions in each of four experimental conditions. These four conditions represented a combination of two levels of information availability and two levels of information management. The two levels of information availability were at the operations order and (1) when changes in the position of other units occurred, and (2) when changes in unit position occurred and any other time during the mission. The two levels of information management were (1) team leader only and (2) team leader with team support.

In missions when access to information on the HMD was limited, team leaders perceived that they expended more effort and were more frustrated. However, in missions when information could be accessed on the HMD at any time, local SA of team leaders, as measured by the number of targets they detected along the course, decreased significantly. The analyses of performance of measures of global SA were technically but not statistically significant. However, the results are suggestive of the potential influence of information availability and information management and the need for further study. As might be expected, team member perceptions of workload were higher when the team provided information management support, but team participation in information management was not found to have a significant effect on measures of global or local SA or on overall mission performance.

14. SUBJECT TERMS

helmet-mounted displays situational awareness team performance
information soldier performance

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